AN EVALUATION OF AIR QUALITY AT TWO SITES IN THE LOWER TOWNSITE OF FORT MCMURRAY

October 1, 1991 to June 30, 1992

Technical Report Series

Alberta ENVIRONMENT

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SUMMARY

Alberta Environment conducts air quality monitoring surveys to measure air pollutant concentrations that are representative of a specific area. The primary objective of air quality monitoring in Fort McMurray is to monitor pollutants that are transported into Fort McMurray from the oil sands facilities located to the north of the city. A secondary objective is to monitor air quality from urban sources within the City of Fort McMurray.

Alberta Environment has monitored air quality at one station in the City of Fort McMurray since 1977. This monitoring station is located in the Athabasca River Valley adjacent to the Snye near McDonald Island (valley station). In late 1990 concerns were expressed by residents of Fort McMurray and Pollution Control Division of Alberta Environment regarding the representativeness of this monitoring location. Residents complained that odours were noticeable in downtown Fort McMurray when the valley monitoring station was measuring low odourous pollutant concentrations. In response to these concerns, the Environmental Quality Monitoring Branch of Alberta Environment installed a second monitoring trailer in downtown Fort McMurray, between Manning Avenue and the Clearwater River, approximately one block northeast of Franklin Avenue (downtown station). Air quality monitoring began at this additional location on October 1, 1991.

This report compares air quality data collected at both monitoring locations for the period October 1, 1991 to June 30, 1992. The valley and downtown stations monitored for carbon monoxide, the coefficient of haze (dust and smoke), hydrogen sulphide, oxides of nitrogen (including nitrogen dioxide and nitric oxide), ozone, sulphur dioxide and total hydrocarbons. Wind direction and speed were also monitored at these two locations. Data analysis includes: (1) a comparison of daily average pollutant concentrations; (2) a comparison of the cumulative frequency distribution of 1-hour average pollutant concentrations; (3) a comparison of the frequency of times that the regulations were exceeded at each station; and (4) an analysis of hydrogen sulphide and sulphur dioxide concentrations greater than their respective odour thresholds. An analysis of odour complaints relative to concentrations of sulphur dioxide, hydrogen sulphide and total hydrocarbons has been completed to relate instrument derived data to the public perception of air quality. The statistical significance of the difference in pollutant concentrations was also examined.

Sulphur dioxide and hydrogen sulphide showed a greater frequency of high concentrations at the valley location. Exceedances of the one-hour regulation for hydrogen sulphide occurred more frequently at the valley station (five times) than the downtown station (one time). Sulphur dioxide and hydrogen sulphide readings at this station are likely attributed to transportation of these pollutants down the Athabasca River Valley during stable meteorological conditions with light northerly winds.

Hydrogen sulphide concentrations greater than the odour threshold for sensitive individuals (3.5 ppb), were more frequent at the valley monitoring station during the monitoring period. Sulphur dioxide concentrations were well below the odour threshold during the monitoring

period. Odours which prompt complaints in the region are likely caused by chemicals such as hydrogen sulphide and other sulphur-containing compounds which originate from the oil sands plants to the north of the city.

Hydrogen sulphide and sulphur dioxide concentrations were found to be substantially greater during times of odour complaints than average values for the entire monitoring period. Concentrations of these pollutants were higher at the valley station when odour complaints were recorded. Wind directions were predominantly north-northeast at the valley station and northwest to north at the downtown station when odour complaints were reported.

Pollutants such as carbon monoxide and the coefficient of haze (dust and smoke), which are produced by urban sources, were generally higher at the downtown monitoring station. Peak 1-hour average concentrations of these pollutants were below Alberta Environment regulations. Higher values of carbon monoxide and the coefficient of haze at this station are due to greater vehicular activity in the downtown core of Fort McMurray. Oxides of nitrogen (including nitrogen dioxide and nitric oxide) concentrations were comparable at both monitoring stations. Nitrogen dioxide concentrations were below ambient air quality regulations. Total hydrocarbon concentrations were also higher at the downtown monitoring station. Vehicular exhaust is a major source of carbon monoxide, oxides of nitrogen and some types of hydrocarbons while traffic movement on sanded or gravel roads is a source of dust and smoke. Other sources of hydrocarbons in the region include industrial activities and natural sources such as trees and vegetation.

Average ozone concentrations for the monitoring period were slightly higher at the downtown station. The frequency of exceedances of the 24-hour regulation for ozone was also higher at the downtown station. Ozone in the Fort McMurray region may result from: (1) the reaction of sunlight with man-made and natural oxides of nitrogen and hydrocarbons; and (2) transport of ozone from the upper atmosphere to ground level. Much of the ozone in the Fort McMurray area may originate from natural, background sources.

As a result of data collected at the valley and downtown stations, it was determined that the valley site is still the most suitable location for monitoring air pollutants that are transported into the Lower Townsite of Fort McMurray from the oil sands facilities. In addition, the data obtained from the valley location also adequately represents air quality of the urban environment within the Lower Townsite of Fort McMurray.

ACKNOWLEDGEMENTS

The successful completion of this project required the cooperation of numerous dedicated individuals. These individuals include D. Kupina who was responsible for reporting of the air quality data and provided technical advice during the study, R. Brassard and his staff for the installation of the monitoring equipment, R. Angle for his technical assistance during the preparation of the report, E. Boyko for calibration of the equipment, and B. MacGougan for the day to day maintenance of the monitoring equipment. Special acknowledgement is also given to J. Hodgins-Ukrainec, P. McInnes and D. Onuczko for providing odour complaint information.

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CO	- carbon monoxide
COH	- coefficient of haze
H_2S	- hydrogen sulphide
NO_2	- nitrogen dioxide
NO	- nitric oxide
NO_x	- oxides of nitrogen
N_2O	- nitrous oxide
O_3	- ozone
SO_2	- sulphur dioxide
THC	- total hydrocarbons
COS	- carbonyl sulphide
CS_2	- carbon disulphide
ppm	- parts per million by volume
ppb	- parts per billion by volume

1. INTRODUCTION

Alberta Environment has monitored air quality in the city of Fort McMurray since February of 1977. In late 1990 concerns from residents of Fort McMurray and from the Pollution Control Division of Alberta Environment were raised regarding the location of the monitoring station. Residents of Fort McMurray were concerned about noticeable odours in downtown Fort McMurray when the monitoring station was recording low concentrations of odourous pollutants. The Pollution Control Division was concerned that the monitoring station was not measuring pollutant concentrations which were representative of downtown Fort McMurray.

In response to these concerns, the Environmental Quality Monitoring Branch of Alberta Environment installed a second air quality monitoring station in downtown Fort McMurray. This station began monitoring on October 1, 1991. The study that follows is a comparison of data collected at the two Fort McMurray monitoring stations from October 1, 1991 to June 30, 1992. The locations of these monitoring stations are shown in Figure 1.1.

The objectives of the Alberta Environment air quality monitoring program are to:

- *provide data for the assessment of existing air quality relative to regulations and objectives;*
- *inform the public on the status of air quality;*
- *monitor air quality in representative urban environments to document human exposure to air pollution;*
- *report long-term trends in air quality; and*
- *undertake monitoring in special problem areas.*

The specific objective of the Fort McMurray air quality monitoring station is to monitor air quality that would represent both industrial pollutants which are transported into Fort McMurray from the oil sands region while also monitoring air pollutants that are generated within the urban environment of Fort McMurray.

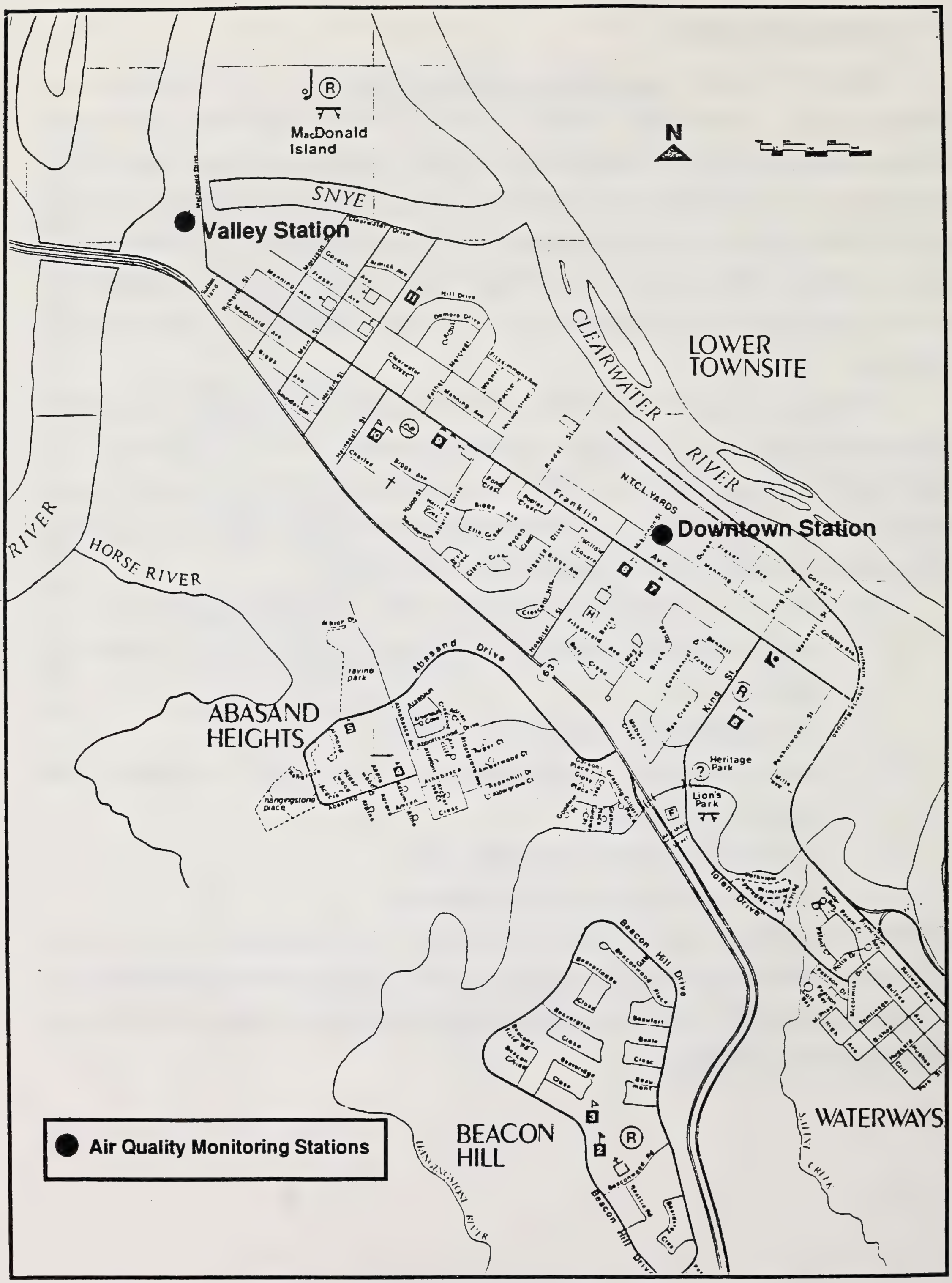

Figure 1.1. Location of Fort McMurray monitoring stations.

1.1 Background

The Fort McMurray monitoring station was established in February of 1977 as part of the Alberta Oil Sands Environmental Research Program (AOSERP). This monitoring station location was chosen to: (1) measure pollutant levels in an area which was experiencing rapid urban growth; and (2) monitor pollutants which may be transported down the Athabasca River valley from the industrial facilities north of the city (Strosher 1978). Two other continuous monitoring stations were installed at Bitumount and Birch Mountain as part of AOSERP. These stations have since been decommissioned. Alberta Environment has continued to maintain the Fort McMurray monitoring station, as part of the network of urban monitoring stations, after the conclusion of AOSERP in 1980.

Alberta Environment installed an ambient air quality monitoring station in the Thickwood Heights area of Fort McMurray from July, 1982 to January, 1983. The purpose of this station was to compare pollutant concentrations in the Thickwood Heights area to those in the Lower Townsite. The results of the program indicated that all pollutant levels (oxides of nitrogen, ozone and sulphur dioxide) were higher at the Thickwood Heights monitoring station than at the Lower Townsite location. For example, maximum 1-hour average sulphur dioxide concentrations were 0.15 ppm (parts per million) and 0.11 ppm, respectively, at the Thickwood Heights and Lower Townsite monitoring locations.

A number of short-term mobile monitoring projects have been undertaken in the Fort McMurray area. These projects were usually initiated in response to odour complaints from local residents.

1.2 Topography

Local topography in the Fort McMurray area is defined by the Athabasca and Clearwater Rivers (Figure 1.2). The Athabasca River is oriented southwest-northeast as it flows into the city from the southwest. This orientation changes to south-north as the Athabasca River merges with the Clearwater River just north of downtown Fort McMurray. Downtown (Lower Townsite) Fort McMurray is located on a relatively flat plain which lies between the Athabasca and Clearwater Rivers. Other areas of the city include Thickwood Heights and Timberlea to the northwest, Abasand Heights to the southwest, Beacon Hill to the south and Waterways to the southeast of downtown. Thickwood Heights, Timberlea, Abasand Heights and Beacon Hill are primarily residential areas that are situated at substantially higher elevations than downtown Fort McMurray. Waterways is partially residential and light industrial and is at a lower elevation than downtown. The terrain surrounding the city consists of rugged, tree-covered hills.

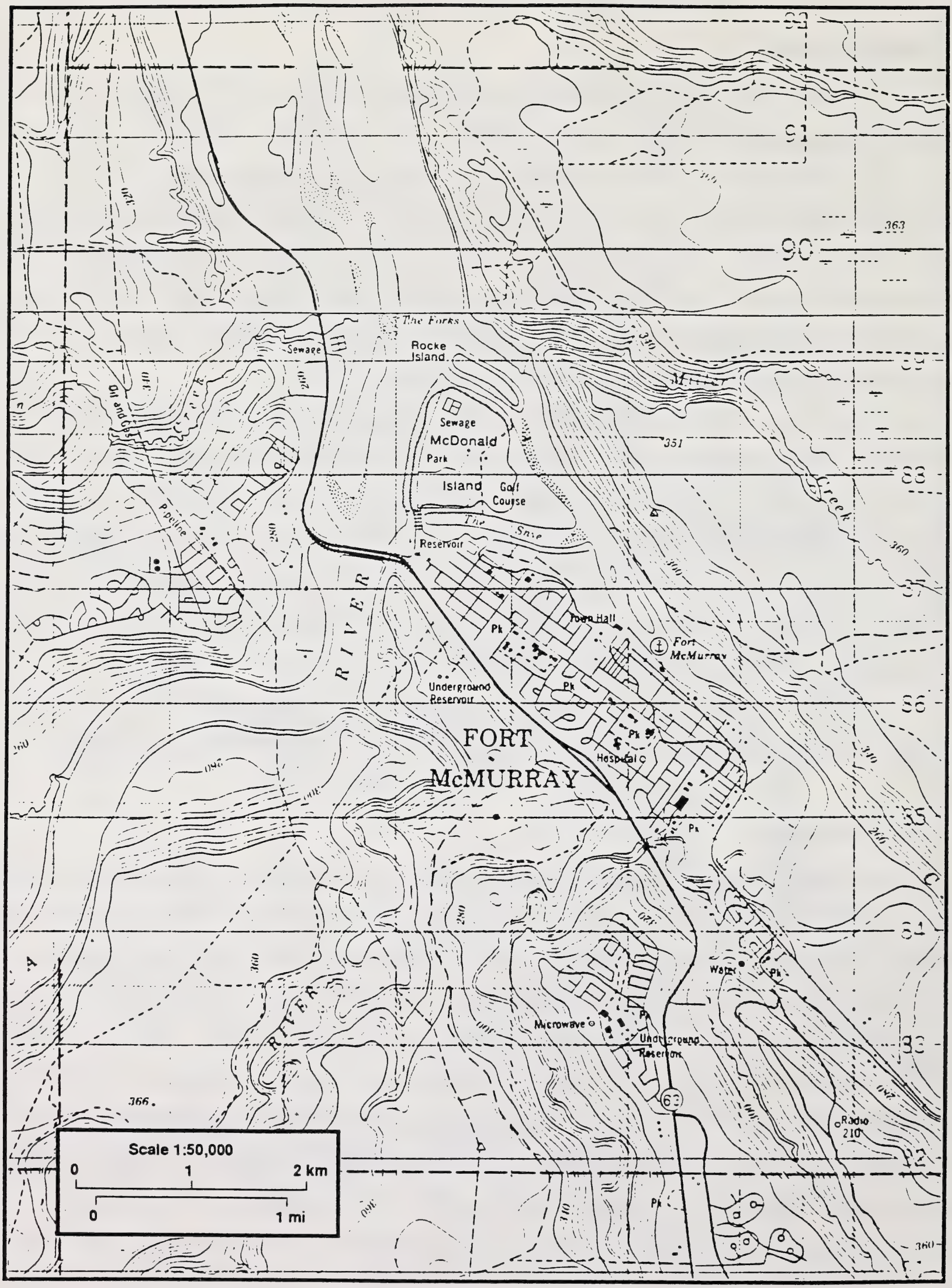

Figure 1.2. Local topography of the Fort McMurray area.

2. DESCRIPTION OF MONITORING PROGRAM

The monitoring program consisted of two continuous air quality monitoring trailers. Each trailer was equipped to monitor for carbon monoxide, the coefficient of haze (dust and smoke), hydrogen sulphide, oxides of nitrogen (including nitric oxide and nitrogen dioxide), ozone, sulphur dioxide and total hydrocarbons. Wind direction and wind speed data was also collected at both monitoring locations. Hourly measurements of these parameters were collected and are available for analysis.

2.1 Site Description

The location of the Fort McMurray air quality monitoring stations are indicated in Figure 1.1. The original air quality monitoring station (referred to as the valley station) is located on the east bank of the Athabasca River, west of MacDonald Drive and adjacent to the Snye. This station is located northwest of the major downtown area. The valley station is located at 56.73° N latitude and 111.39° W longitude. The second monitoring station (referred to as the downtown station) is located between Manning Avenue and the Clearwater River, approximately one block northeast of Franklin Avenue in downtown Fort McMurray. This station is located at a latitude of 56.72° N and a longitude of 111.35° W. Both stations are situated at an elevation of approximately 250 m ASL.

2.2 Air Quality Parameters

2.2.1 Carbon Monoxide (CO)

Carbon monoxide, a common pollutant in urban areas, is a colourless, odourless gas. The majority of the CO found in urban air comes from incomplete combustion of carbon-based fuels. The primary source of urban CO is motor vehicles, with much smaller contributions from fireplaces, industrial sources, aircraft and natural gas combustion.

The relationship between vehicular traffic and CO is apparent at urban locations during morning and evening rush hours. CO concentrations also fluctuate seasonally. The highest concentrations occur during the late autumn, winter and early spring because: (1) in cold weather, motor vehicles run less efficiently; (2) vehicle warm-up and idling times are increased; and

(3) meteorological conditions, such as stable atmospheric conditions and low wind speeds result in decreased dispersion.

CO is monitored continuously by either non-dispersive infrared photometry or gas filter correlation. The non-dispersive infrared photometry process is based upon the absorption of infrared light by CO. Gas filter correlation is operated on the same principle as non-dispersive infrared photometry and is also based on the absorption of light by CO.

The regulations governing the maximum permissible concentration of CO are based on the prevention of human health effects. In regulating CO, Alberta has adopted Environment Canada's most rigorous ambient air quality regulations. Maximum permissible CO concentrations are:

- 13.0 ppm as a 1-hour average concentration; and
- 5.0 ppm as an 8-hour average concentration.

2.2.2 Coefficient of Haze (COH)

The interaction of particles with sunlight and atmospheric moisture can result in diminished visibility (haze). The coefficient of haze is an index which corresponds to the reduction of transmitted light, or visibility reduction, due to particulate matter in the form of dust and smoke. Sources of dust and smoke include road dust, wind-blown soil, industrial sources, automobile emissions and agricultural activities.

Air samples are collected continuously by drawing a known volume of air through a filter paper for a period of one hour. The soiling properties of the sample are measured by the reduction of light transmission through the filter tape. This reduction is reported as the coefficient of haze per 1000 linear feet of air sample. This method does not measure the absolute concentration or deposited mass of particulate but rather is an index of fine suspended particulate matter in the air.

Guidelines regarding the COH are based on visibility reduction. Alberta Environment has established that:

- 90% of the COH readings per month shall be less than 1.0 COH unit.

2.2.3 Hydrogen Sulphide (H_2S)

Hydrogen sulphide is a colourless gas with a characteristic rotten egg odour. H_2S is produced both naturally and through industrial processes. Natural sources of H_2S include coal, natural gas, oil, sulphur hot springs, sloughs, swamps and lakes. It is also produced under anaerobic conditions in the decomposition of sulphur-containing bacteria. Decomposition of sulphur-containing bacteria is responsible for the rotten egg odour commonly associated with marshes, sewers, and sewage lagoons.

While most of the H_2S in the atmosphere is from natural sources, industrial sources have a significant impact on the environment. These industrial sources are primarily petroleum refining, natural gas plants, petrochemical complexes, coke oven plants, and pulp and paper mills employing the kraft pulping process.

H_2S is measured continuously by pulsed fluorescence. In this method, air is drawn through a sample chamber where it is irradiated with pulses of ultra-violet light. Any H_2S in the sample is excited to a higher energy level and upon returning to is its original state, light or fluorescence is released. The amount of fluorescence measured is proportional to the H_2S concentration.

The regulations governing the maximum permissible concentration of H_2S is based on the odour threshold although, many individuals can smell H_2S at levels below the ambient regulations. In regulating H_2S, Alberta has adopted Environment Canada's most rigorous ambient regulation with a maximum permissible concentration of:

- 0.010 ppm as a 1-hour average concentration; and
- 0.003 ppm as a 24-hour average concentration.

2.2.4 Oxides of Nitrogen (NO_x)

Oxides of nitrogen appear in the ambient atmosphere as nitrogen dioxide (NO_2), nitric oxide (NO) and nitrous oxide (N_2O). Alberta Environment monitors for NO_2, NO, and NO_x on a continuous basis.

During high temperature combustion, as in the burning of natural gas, coal, oil and gasoline, atmospheric nitrogen may combine with molecular oxygen to form NO. NO is colourless, odourless and has no known toxic effects. Most of the NO is rapidly oxidized to

form NO_2. NO_2 is a reddish-brown gas with a characteristic pungent odour. NO_2 is partially responsible for the brownish discolouration of the lower atmosphere near urban areas.

Nitrous oxide is a naturally occurring, sweet smelling, non-toxic gas in the ambient atmosphere. For the purposes of air quality monitoring, total oxides of nitrogen (NO_x) is considered to be the sum of the concentration of NO_2 and NO. Nitrous oxide is not included as a contributor to total oxides of nitrogen in ambient air quality monitoring because ambient concentrations are generally very low.

In Alberta, about 38% of NO_x emissions are contributed by the oil and gas industry, 29% by transportation and 16% by power plants. The remaining 17% originate from natural gas and heating fuel combustion, agricultural fuel consumption and other industries (Alberta Environment 1990).

Oxides of nitrogen are measured continuously by the principle of chemiluminescence. In this method, the air sample is split into two pathways. In the first pathway, the NO concentration is measured by mixing ozone with the sample and detecting the amount of visible light produced when NO_2 reacts with O_3. In the second pathway, all the NO_2 in the sample is reduced to NO by a catalytic converter. The difference between the two readings is the concentration of NO_2.

The regulations governing the maximum permissible concentration of NO_2 are based on the prevention of human health effects. In regulating NO_2, Alberta has adopted the most rigorous ambient regulations set by Environment Canada with a maximum average concentration of:

- 0.21 ppm as a 1-hour average concentration;
- 0.11 ppm as a 24-hour average concentration; and
- 0.03 ppm as an annual arithmetic average.

There are no regulations for ambient concentrations of NO and NO_x.

2.2.5 Ozone (O_3)

At normal ambient concentrations, O_3 is a colourless, odourless gas. However, O_3 does have a characteristic sharp odour when at very high concentrations (i.e., electrical discharges associated with arcing electric motors and lightning storms). Unlike many other pollutants, O_3 is not emitted into the atmosphere directly by man's activities, but is produced through the inter-

reaction of other atmospheric constituents. In the upper atmosphere, O_3 is a naturally-occurring compound; in the lower atmosphere, O_3 is the primary end-product of photochemical reactions involving oxides of nitrogen and reactive hydrocarbons with ultra-violet light from the sun. O_3 is formed through the dissociation of NO_2 by sunlight to yield an oxygen atom, which may react with molecular oxygen to form an O_3 molecule.

The highest levels of O_3 generally occur during the spring and summer months. In the summer, the hours of sunlight are longer and stagnant meteorological conditions can cause reactive pollutants to remain in an area for several days. Occasionally, meteorological conditions can result in stratospheric O_3 being brought down to ground level, a phenomenon known as tropopause folding. The build-up of ozone precursors such as NO_x and hydrocarbons during the winter may also lead to elevated spring O_3 concentrations.

In Alberta, O_3 concentrations tend to be lower in urban locations than rural locations. Cities act as sinks, destroying O_3 that is formed in or near the city. In urban areas, NO emitted from motor vehicles reacts with O_3 to produce NO_2 and molecular oxygen. By contrast, in rural areas with less vehicles, O_3 (produced by the reaction of sunlight with NO_x and natural hydrocarbons or from tropopause folding) is less prone to destruction by NO.

O_3 is continuously monitored by either the chemiluminescence or ultra-violet photometry processes. The chemiluminescence process involves the reacting of an air sample with ethylene. The reaction of ethylene and O_3 produces light. The intensity of the light produced is proportional to the O_3 concentration. The ultra-violet photometry process uses a mercury vapour lamp as a source of ultra-violet radiation. This method determines the O_3 concentration by the amount of ultra-violet radiation that is absorbed by the O_3 in the sample.

The regulations governing the maximum permissible concentration of O_3 are based on the prevention of human health effects. Alberta has high natural levels of O_3 and frequently, especially in rural locations, exceeds the 24-hour regulation (Angle and Sandhu 1986). The ambient air quality regulations for O_3 in Alberta are:

- 0.082 ppm as a 1-hour average concentration; and
- 0.025 ppm as a 24-hour average concentration.

2.2.6 Sulphur Dioxide (SO_2)

Sulphur dioxide is a heavy, colourless gas with a pungent odour. Processes such as combustion of fossil fuels, smelting and roasting of sulphur containing ores, kraft and sulphite wood pulping, and sour gas processing produce most of the man-made SO_2 in the atmosphere.

In Alberta, during 1988 an estimated 626 kilotonnes of SO_2 were emitted into the atmosphere from man-made sources. About 38% of the SO_2 emissions was contributed by sulphur extraction gas plants; oil sands plants and coal-fired power plants contributed about 29% and 16%, respectively. The remaining 15% was emitted from sources such as gas plant flares, oil refineries, pulp and paper mills and fertilizer plants(Alberta Energy 1990).

SO_2 is monitored continuously by pulsed fluorescence. In this method, air is drawn through a sample chamber where it is irradiated with pulses of ultra-violet light. Any SO_2 in the sample is excited to a higher energy level and upon returning to its original state, light or fluorescence is released. The amount of fluorescence measured is proportional to the SO_2 concentration.

The regulations governing the maximum permissible concentration of SO_2 are based on preventing damage to vegetation. At these levels, no known health effects are detectable. In regulating SO_2, Alberta has adopted Environment Canada's most rigorous ambient regulation:

- 0.17 ppm as a 1-hour average concentration;
- 0.06 ppm as a 24-hour average concentration; and
- 0.01 ppm as an annual average concentration.

2.2.7 Total Hydrocarbons (THC)

The term "total hydrocarbons" refers to the combined concentration of two broad categories of organic compounds: reactive and nonreactive hydrocarbons. The non-reactive component is primarily methane, a colourless, odourless gas that is naturally present in the atmosphere at concentrations of about 1.5 ppm. The reactive component is essentially organic compounds other than methane that are usually present in much lower concentrations. Reactive hydrocarbons are especially important because they will react with nitrogen oxides in the presence of sunlight to form ozone.

Natural sources of hydrocarbons include trees and other vegetation, and the decay of animal and plant material. The primary man-made sources of hydrocarbons are motor vehicles, gasoline marketing tanks and storage tanks. Smaller amounts of hydrocarbons are emitted by sources such as the petroleum and chemical industries, dry cleaning, fireplaces, natural gas combustion and aircraft traffic. Motor vehicle emissions of hydrocarbons are the result of inefficient combustion.

Alberta currently has no ambient air quality regulations for hydrocarbons. Hydrocarbons are monitored continuously by a hydrogen flame ionization detector. When burned, carbon-hydrogen bonds break creating ions that conduct an electric current. This current is then measured by an electrometer to give a signal proportional to the number of ions.

3. DATA ANALYSIS

One-hour average pollutant data are available for the period October 1, 1991 to June 30, 1992 from the Fort McMurray valley and downtown monitoring stations. Analysis of these data involved: (1) presentation of wind direction frequencies; (2) comparing daily average pollutant concentrations; (3) comparing the cumulative frequency distribution of pollutant concentrations; (4) applying statistical test to data to determine if differences in the data are significant; (5) an analysis of exceedances of the regulations or guidelines; and (6) an analysis of hydrogen sulphide and sulphur dioxide concentrations relative to their respective odour thresholds and an analysis of pollutant concentrations during odour events. A summary of the data collected from the valley and downtown monitoring stations is presented in Appendices 7.2 and 7.3.

3.1 Analysis of Wind Data

A wind direction frequency distribution for the valley and downtown monitoring stations is presented in Figure 3.1. At both stations, the majority of the wind directions had northerly and southerly components. At the valley station, 15% of the winds were from the north to north-northeast directions. Wind directions from the south and south-southeast were also common at the valley station (15%). The most common wind directions at the downtown station were northwest to north (35%) and southeast to south-southeast (37%). Wind direction frequencies at the two stations reflect the location of the stations with respect to local topographical features (i.e. the Athabasca River valley in the vicinity of the valley station and the Clearwater River valley to the east of the downtown station). Calm winds were recorded 16.1% of the time at the valley station compared to only 2.5% of the time at the downtown station. The high frequency of calm winds at the valley station may indicate a malfunction in the wind instrument at this station. This malfunction may have been caused by occasional freezing of the wind instrument because of the occurrence of relatively high humidities and cold temperatures in the river valley. Almost 37% of wind data at the valley station is not available due to instrument malfunction.

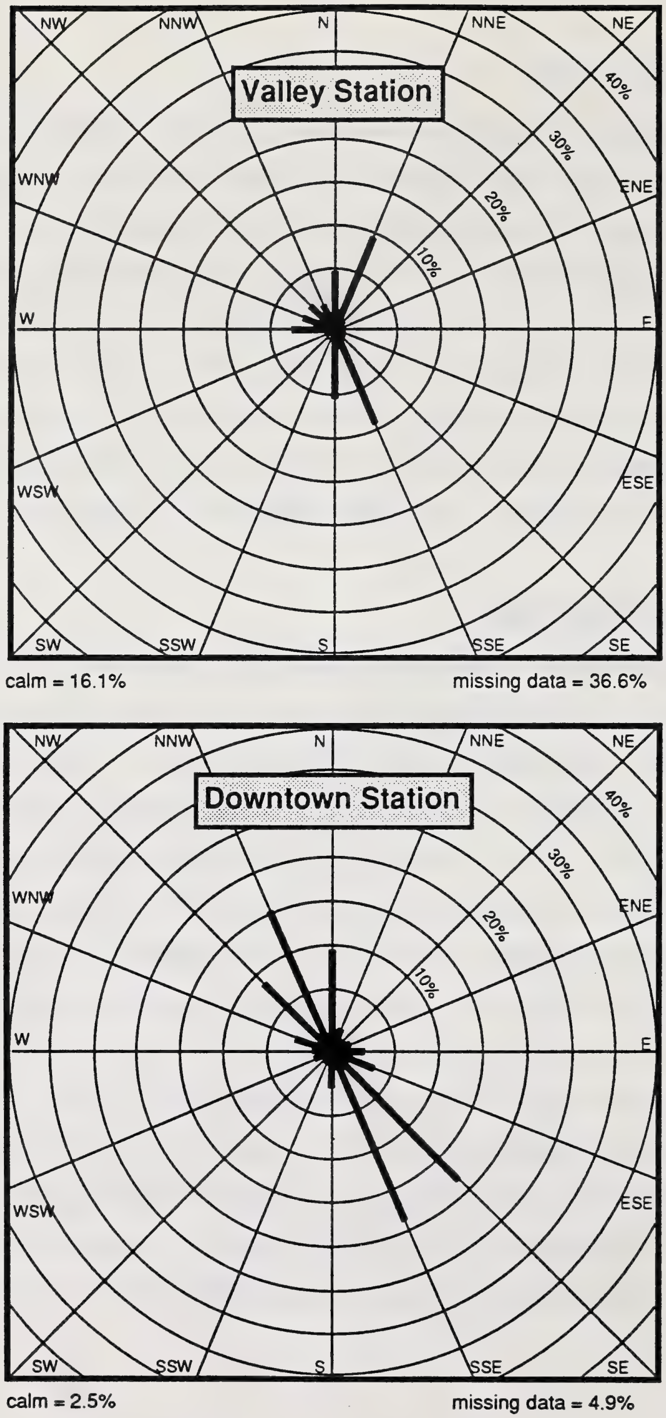

Figure 3.1. Wind direction frequency distribution at valley and downtown monitoring stations (October 1, 1991 to June 30, 1992).

3.2 Daily Average Pollutant Concentrations

Daily average CO, COH (dust and smoke) and O_3 values are presented in Figure 3.2. Daily average values of these pollutants are were generally higher at the downtown monitoring station than the valley station. This difference was the greatest for CO from October 22 to December 5, 1991 where CO concentrations were substantially greater for the majority of this time period. CO concentrations at the downtown station were 2.5 to 3 times greater than at the valley station for numerous days in November. Average CO and COH and values for the monitoring period were about 31% and 40% higher at the downtown monitoring station, respectively. Ozone concentrations were also higher the majority of the time at the downtown station. Average O_3 concentrations were 10% higher at the downtown monitoring station based on the average value for the monitoring period.

Figure 3.3 shows daily average concentrations of NO_2, NO and NO_x at both monitoring stations. Again, concentrations of these pollutants appeared to be higher the majority of the time at the downtown monitoring station. The difference in the concentration of these compounds at the two stations was not as apparent as for CO and COH. This result is emphasized by the average values for the period which were about 5% ,13% and 13% higher at the downtown station for NO_2, NO and NO_x, respectively.

As shown in Figure 3.4, daily average THC concentrations were substantially higher at the downtown monitoring station. Daily average hydrocarbon concentrations were higher at the valley station for about 15 days at the end of October. Average THC concentrations for the monitoring period at the downtown station were 26% higher than at the valley station.

Figure 3.4 also shows daily average concentrations for H_2S and SO_2. In contrast to the pollutants mentioned previously, concentrations of these pollutants appeared to be higher at the valley monitoring station for the majority of the time. However, the average H_2S concentration for the monitoring period was slightly higher at the downtown station. The average SO_2 concentration for the period was 15% higher at the valley station. Peak daily H_2S values are generally higher at the valley station.

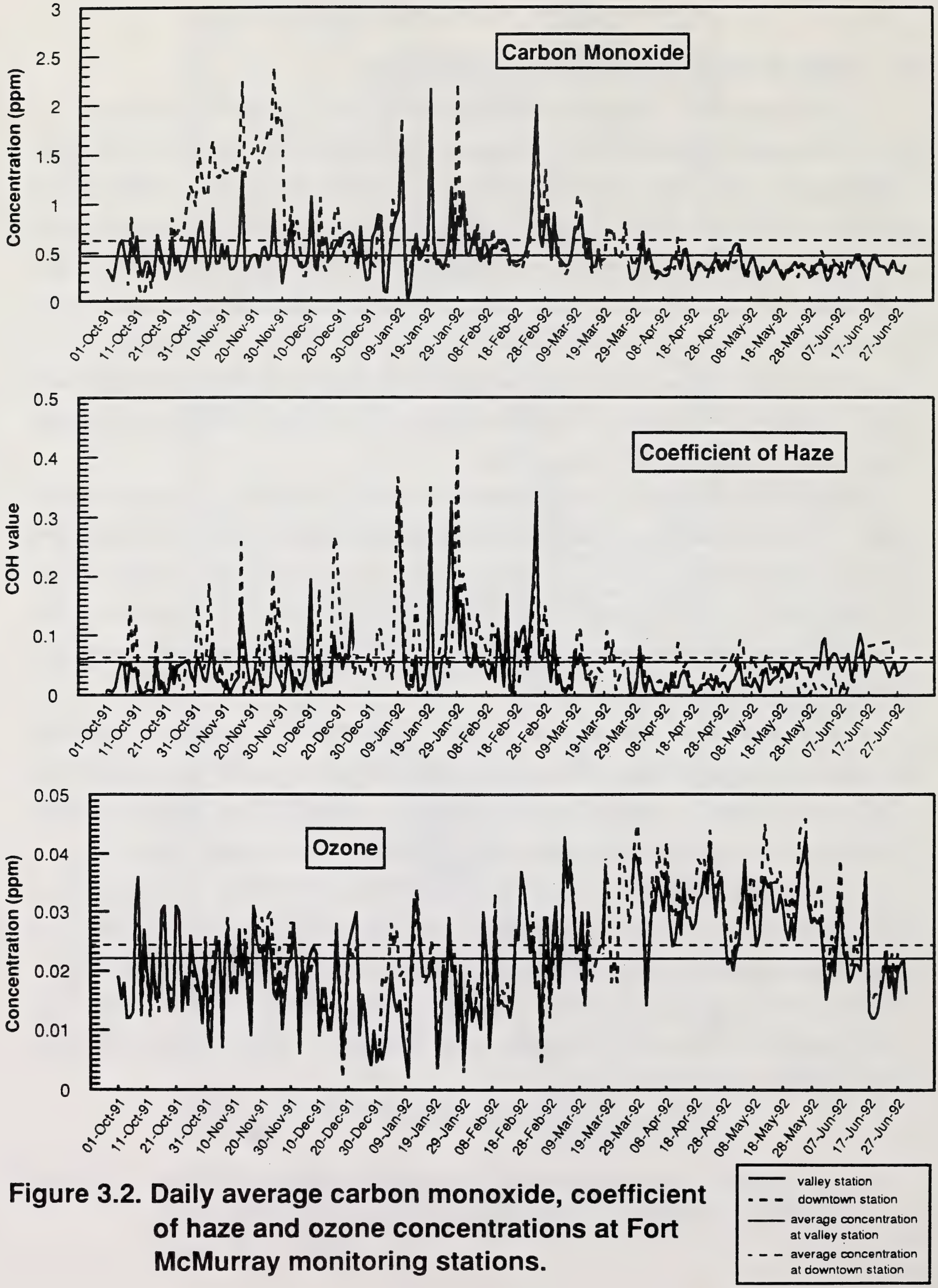

Figure 3.2. Daily average carbon monoxide, coefficient of haze and ozone concentrations at Fort McMurray monitoring stations.

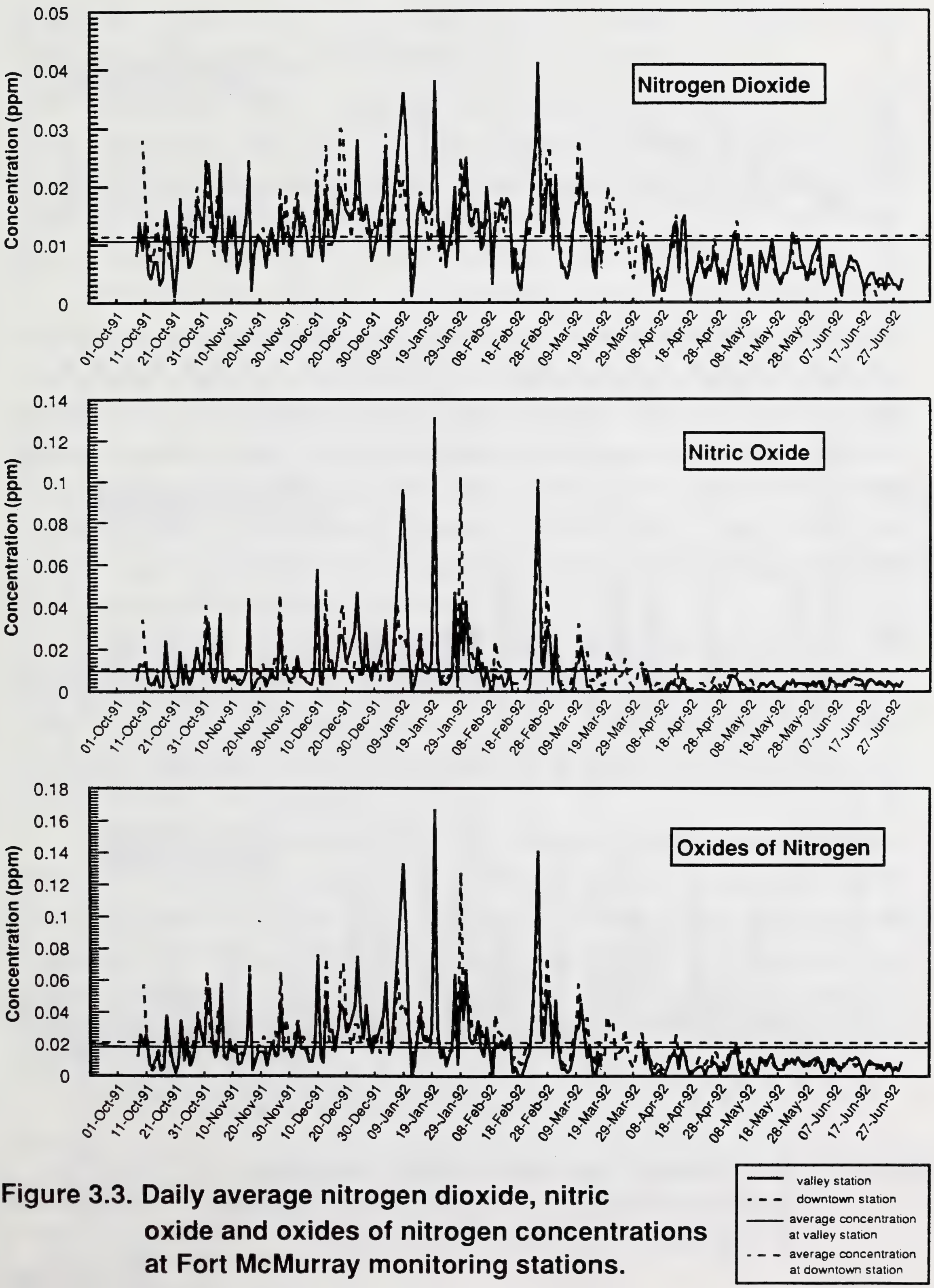

Figure 3.3. Daily average nitrogen dioxide, nitric oxide and oxides of nitrogen concentrations at Fort McMurray monitoring stations.

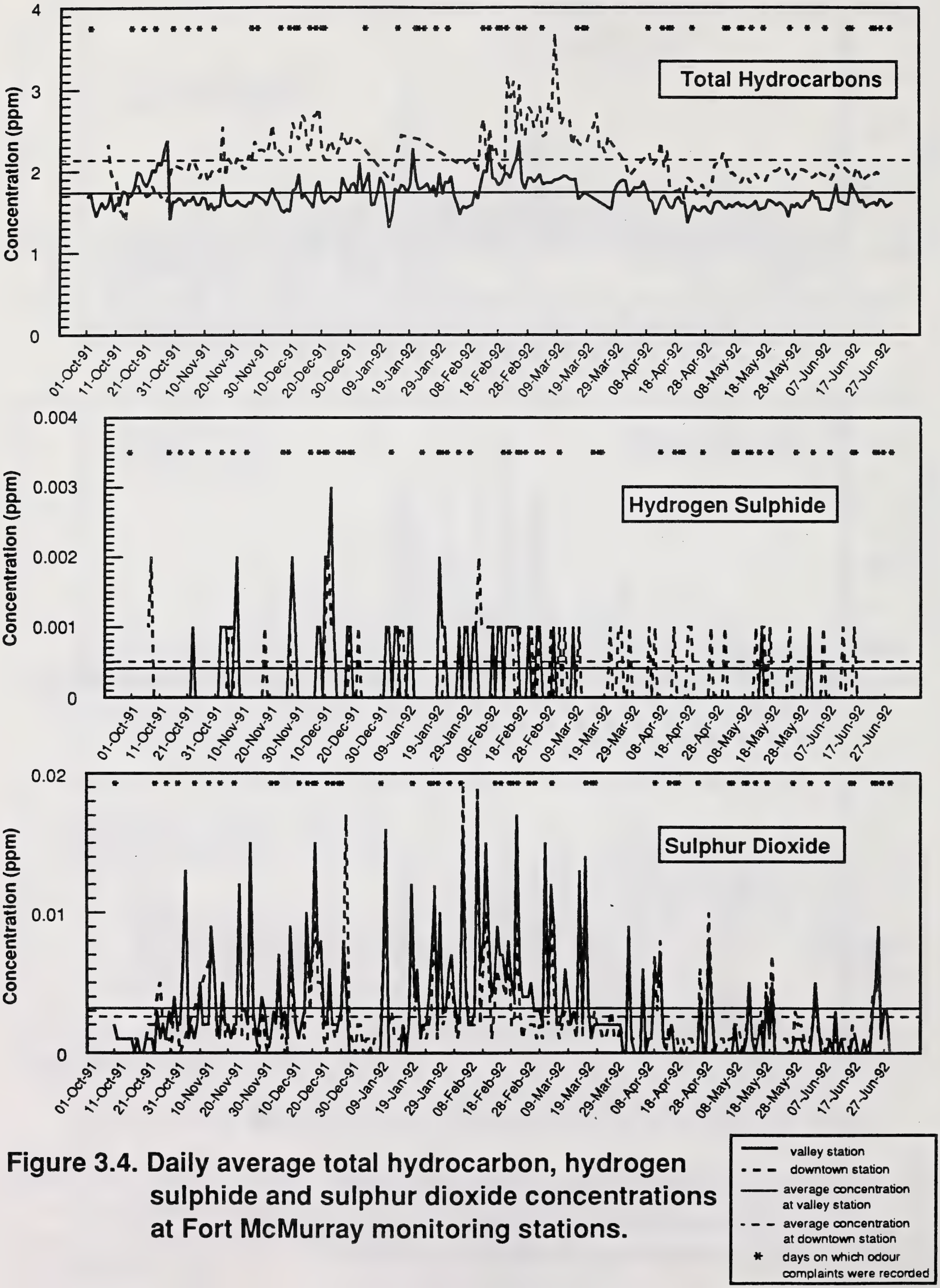

Figure 3.4. Daily average total hydrocarbon, hydrogen sulphide and sulphur dioxide concentrations at Fort McMurray monitoring stations.

3.3 Cumulative Frequencies of Pollutant Concentrations

An important method of visually determining differences between pollutant data from the valley and downtown stations is by examining the cumulative frequency distributions for the pollutant data sets. The cumulative frequency distribution will reveal added detail as to how frequencies of specific concentrations differ between the two stations. Cumulative frequencies for CO, COH, H_2S, NO_2, NO, NO_x, O_3, SO_2 and THC are illustrated in Figures 3.5 to 3.7.

With the exception of the lower 50% of the frequency distribution, CO concentrations were higher at the downtown station than the valley station. For the first 75% of the frequency distribution, the frequency of COH values at the downtown and valley stations are equal. For the upper 25% of the distribution (i.e. higher COH values) the frequency of COH values at the downtown station is higher. This result indicates that the frequencies of CO concentrations greater than 0.3 ppm and COH values greater than 0.1 COH units were higher at the downtown monitoring station. The cumulative frequency distribution for O_3 shows that higher concentrations for all frequencies were evident at the downtown monitoring station. However, this difference is not as apparent as for CO and COH.

Frequencies of NO_2, NO and NO_x were similar at both monitoring stations. NO_2 concentrations at the downtown station were slightly higher for the first 50% of the frequency distribution at the downtown station and slightly higher at the valley station from the 50th to 90th percentiles. Frequencies of NO and NO_x concentrations above 0.12 and 0.16 ppm, respectively, are slightly higher at the valley station.

Higher THC concentrations at the downtown station are evident for the entire frequency distribution. This difference is substantial for all THC frequencies. H_2S concentrations were the same at both stations for the lower 99% of the frequency distribution (concentrations less than 0.002 ppm). For H_2S concentrations that were greater than 0.002 ppm, higher frequencies were evident at the valley monitoring station. For SO_2, concentrations greater than 0.001 ppm occurred more frequently at the valley station for the upper 50% of the frequency distribution.

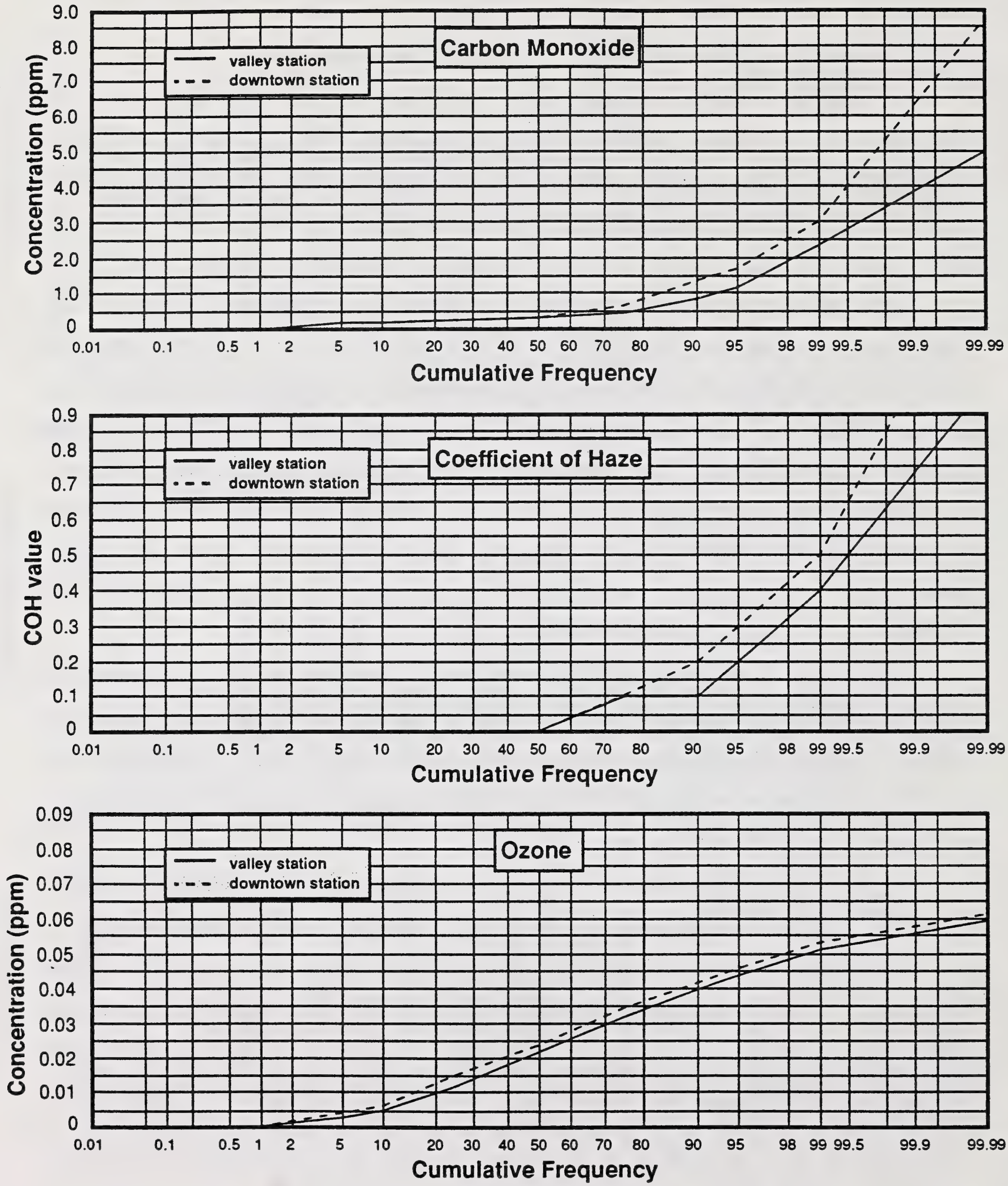

Figure 3.5. Cumulative frequency distribution of carbon monoxide, coefficient of haze and ozone concentrations at Fort McMurray monitoring stations.

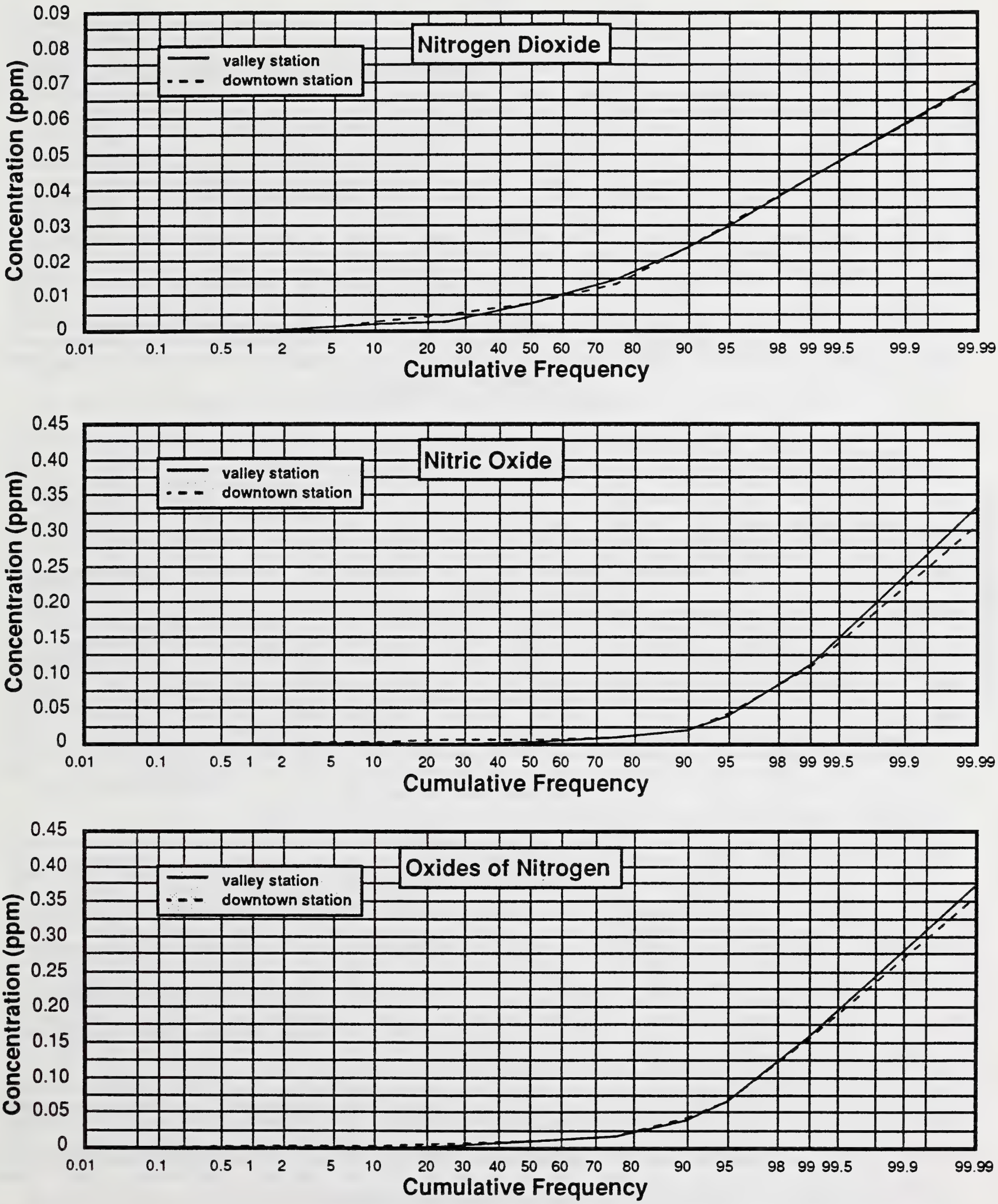

Figure 3.6. Cumulative frequency distribution of nitrogen dioxide, nitric oxide and oxides of nitrogen concentrations at Fort McMurray monitoring stations.

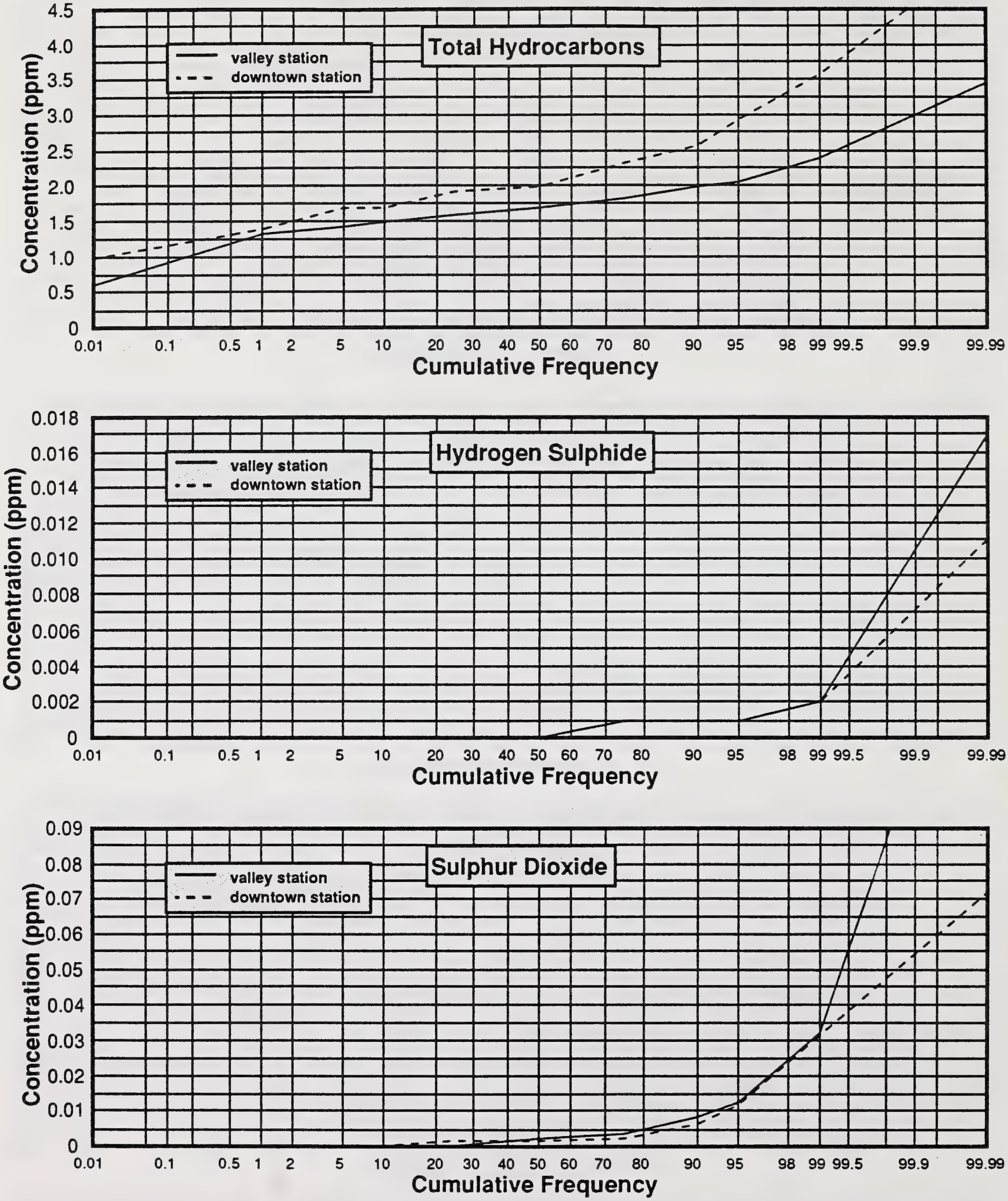

Figure 3.7. Cumulative frequency distribution of total hydrocarbons, hydrogen sulphide and sulphur dioxide concentrations at Fort McMurray monitoring stations.

3.3.1 Central and Extreme Value Statistics

The central (average and median) and extreme (99th percentile and maximum) pollutant concentrations for the monitoring period are given in Table 3.1. This table summarizes the results that are apparent from the cumulative frequency distribution graphs. For central value statistics higher concentrations of CO, COH, NO_2, NO, NO_x, O_3 and THC were evident at the downtown monitoring station. Higher central values for SO_2 were recorded at the valley location. The average value for H_2S was slightly higher at the downtown monitoring location. Extreme values statistics show a similar pattern for CO, COH, O_3 and THC. Maximum values for H_2S, SO_2 and NO_2, NO and NO_x were greater at the valley station.

3.4 Statistical Tests

Two non-parametric, paired data statistical tests were used to compare the air quality data collected at the valley and downtown stations. These test are referred to as the sign test and Wilcoxon signed rank test. The formulation for these test are described in numerous statistics text books (Gilbert 1987, Keeping 1962, Zar 1974). The application procedures for these statistical tests are explained in Appendices 7.4 and 7.5.

3.4.1 The Sign Test

The sign test looks at the magnitude of the differences between data that is collected coincidentally (paired data). The advantages of this test are that: (1) the statistic is simple to calculate; (2) the shape of the underlying distribution is not taken into account; (3) it is able to account for concentrations below the limit of detection. The sign test will determine whether the concentration at each individual observation from one station are likely to be greater than the individual observation at the other station.

Table 3.2 shows the frequency of time that individual concentrations for specific times were greater at valley and downtown stations as well as the large sample Z statistic from the sign test for each pollutant. For large samples, such as those observed in these data (i.e. 6576 data points) it is assumed that the Z statistic can be compared with the cumulative normal distribution (Gilbert 1987). For a 95% level of confidence (α=0.05), the value of $Z_{1-\alpha/2}$ from the cumulative

Table 3.1. **Comparison of average, median and extreme value statistics at the Fort McMurray valley and downtown monitoring locations.**

Pollutant	Station	Average (ppm)	Median (ppm)	99th % (ppm) [a]	Maximum (ppm)
Carbon Monoxide	Valley	0.48	0.4	2.4	5.0
	Downtown	0.63	0.4	3.0	8.7
Coefficient of Haze[b]	Valley	0.05	0.0	0.4	1.0
	Downtown	0.07	0.0	0.5	1.5
Hydrogen Sulphide	Valley	0.0004	0.000	0.002	0.017
	Downtown	0.0005	0.000	0.002	0.011
Nitrogen Dioxide	Valley	0.0106	0.008	0.044	0.070
	Downtown	0.0111	0.008	0.044	0.069
Nitric oxide	Valley	0.0095	0.003	0.119	0.334
	Downtown	0.0107	0.004	0.117	0.309
Oxides of Nitrogen	Valley	0.0183	0.009	0.159	0.372
	Downtown	0.0206	0.011	0.157	0.352
Ozone	Valley	0.0220	0.022	0.051	0.059
	Downtown	0.0243	0.024	0.053	0.061
Sulphur Dioxide	Valley	0.0031	0.001	0.032	0.140
	Downtown	0.0027	0.001	0.031	0.072
Total Hydrocarbons	Valley	1.71	1.7	2.4	3.4
	Downtown	2.15	2.0	3.6	7.3

a - 99% of values are below this concentration.
b - units are COH units.

Table 3.2. **Number of times that concentrations were greater at either the valley or downtown monitoring stations and the calculated large sample Z statistic from the sign test.**

Pollutant	# of times that 1-hour concentration was greater at the valley station	# of times that 1-hour concentration was greater at the downtown station	# of times that 1-hour concentration was the same at both stations	# of missing or invalid 1-hour data	Large sample Z statistic
Carbon Monoxide	2086 (32%)	2640 (40%)	1298 (20%)	552 (8%)	8.04
Coefficient of Haze	856 (13%)	1218 (19%)	2971 (45%)	1531 (23%)	7.93
Hydrogen Sulphide	839 (13%)	1084 (16%)	4146 (63%)	507 (8%)	5.56
Nitrogen Dioxide	2422 (37%)	2687 (41%)	616 (9%)	851 (13%)	3.69
Nitric oxide	1817 (28%)	3369 (51%)	539 (8%)	851 (13%)	21.54
Oxides of Nitrogen	2019 (31%)	3359 (51%)	347 (5%)	851 (13%)	18.26
Ozone	1574 (24%)	3856 (59%)	504 (8%)	642 (9%)	30.95
Sulphur Dioxide	2129 (32%)	1866 (28%)	1744 (27%)	837 (13%)	-4.15
Total Hydrocarbons	418 (6%)	4192 (64%)	135 (2%)	1831 (28%)	55.57

normal distribution is 1.96. Therefore, if the Z statistic calculated from the sign test lies between -1.96 and 1.96, then we may conclude that differences in the individual observations from the valley and downtown stations are not distinguishable at a 95% level of confidence. If the Z statistic is less than or equal to -1.96 then we may conclude that the individual observations at the valley station are likely to be higher than those at the downtown station or; if the Z statistic is greater than or equal to 1.96, then the individual observations from the downtown station are likely to be greater than those from the valley station at a 95% level of confidence.

The calculated Z statistic for all pollutants is greater than 1.96 or less than -1.96. The sign test Z statistic indicates that individual values CO, COH, oxides of nitrogen (NO_2, NO and NO_x), O_3, THC and H_2S were more likely to be higher at the downtown station than the valley station. Concentrations of SO_2 were more likely to be higher at the valley station based on a 95% level of confidence. The magnitude of the Z score is an indicator of the frequency of times that the concentrations at one station were greater than those at the other. For NO, NO_x, O_3, and

THC, the Z scores indicate that the concentrations of these pollutants were frequently greater at the downtown station.

3.4.2 The Wilcoxon Signed Rank Test

The Wilcoxon signed rank test is a direct expansion of the sign test except that it is based on the rank of the absolute differences between the data points. The test statistic is more difficult to calculate than the sign test but, the Wilcoxon signed rank test has more power to determine differences in the data sets. The Wilcoxon signed rank test also assumes that the underlying distribution is symmetric but, not necessarily normal.

The results of applying this test to the data from the valley and downtown stations are comparable to those of the sign test although some differences are observed. The Z statistic for CO, COH, NO, O_3, and THC indicate that concentrations at the downtown station were more likely to be higher than concentrations at the valley station at a 95% level of confidence. Contrary to the sign test, H_2S, NO_2, and NO_x values were more likely to be higher at the valley station. SO_2 concentrations were also likely to be higher at the valley station. The Z statistic and average rank of concentrations at each station are shown in Table 3.3.

3.5 Exceedances of the Regulations and Guidelines

The number of times that the regulations were exceeded during the monitoring period are displayed in Table 3.4. There are no regulations for NO, NO_x and THC. Regulations for H_2S and O_3 were exceeded at both stations during the monitoring period.

A total of five hours exceeded the 1-hour regulation for H_2S of 0.01 ppm at the valley monitoring station. This is compared to only one exceedance of the 1-hour regulation for H_2S at the downtown station. Wind directions for times when H_2S exceeded the regulation were from the north-northeast at the valley station and from the north-northwest at the downtown station. Wind speeds did not exceed 10 km/hr during times when H_2S exceeded the regulation.

Table 3.3. Average rank of concentrations at valley and downtown monitoring stations and the calculated large sample Z statistic from the Wilcoxon signed rank test.

Pollutant	Average rank at the valley station	Average rank at the downtown station	Large sample Z statistic
Carbon Monoxide	1891	2737	17.48
Coefficient of Haze	975	1081	8.84
Hydrogen Sulphide	1004	930	-3.40
Nitrogen Dioxide	2580	2532	-2.63
Nitric oxide	2590	2595	18.72
Oxides of Nitrogen	2693	2687	-15.76
Ozone	2520	2795	29.49
Sulphur Dioxide	2240	1721	-10.67
Total Hydrocarbons	1208	2415	53.22

Table 3.4 Number of times that pollutant levels exceeded the regulations or guidelines at valley and downtown monitoring stations

Pollutant	Valley Station				Downtown Station			
	1-hour	8-hour	24-hour	1-month	1-hour	8-hour	24-hour	1-month
Carbon Monoxide	0	0	n/a	n/a	0	0	n/a	n/a
Coefficient of Haze	n/a	n/a	n/a	0	n/a	n/a	n/a	0
Hydrogen Sulphide	5	n/a	0	n/a	1	n/a	0	n/a
Nitrogen Dioxide	0	n/a	0	n/a	0	n/a	0	n/a
Ozone	0	n/a	95	n/a	0	n/a	110	n/a
Sulphur Dioxide	0	n/a	0	n/a	0	n/a	0	n/a

n/a not applicable.

The 24-hour regulation for O_3 was exceeded a total of 95 and 110 days at the valley and downtown stations, respectively. Wind directions at the valley station during these times were from the north and north-northeast about 20% of the time and from the west to north-northwest approximately 14% of the time. Wind directions during times when the 24-hour regulation for O_3 was exceeded at the downtown station were from the northwest to north 41% of the time and from the southeast and south-southeast 31% of the time.

3.6 Analysis of Odour Events

Odours in the ambient air may be caused by a variety of man-made and naturally occurring compounds. In the Fort McMurray area, industrial operations to the north of the city and the rapid urbanization of the city (i.e. increased traffic density) may lead to episodes when pollutant concentrations are high enough to be detected as odours by most individuals. Chemicals which may cause odours from the oil sands activities to the north include sulphur-containing compounds such as hydrogen sulphide, sulphur dioxide, thiophenes, carbonyl sulphide, carbon disulphide, ethyl mercaptans and methyl mercaptans.

Sulphur-containing compounds such as hydrogen sulphide, carbonyl sulphide, carbon disulphide, thiophenes, ethyl mercaptans and methyl mercaptans are emitted by fugitive sources in the oil sands region. These fugitive emission sources include extraction and upgrading plants, mine areas, effluent ponds, recycle ponds, tailings ponds, settling ponds as well as other fugitive emission sources (Concord Scientific Corporation 1988). Sulphur-containing compounds such as sulphur dioxide and carbonyl sulphide may be emitted directly by stack sources in the oil sands area.

Odour events were analyzed by: (1) assessing hydrogen sulphide and sulphur dioxide concentrations greater than their respective odour thresholds; and (2) looking at concentrations of hydrogen sulphide, sulphur dioxide and total hydrocarbons during times when odour complaints were reported in downtown Fort McMurray. Wind directions frequencies during odour events were also evaluated.

3.6.1 Hydrogen Sulphide and Sulphur Dioxide

Most individuals can smell hydrogen sulphide at a concentration of 0.01 ppm (National Research Council, 1981). Although, more sensitive individuals can detect hydrogen sulphide at concentrations of 0.0035 ppm (3.5 parts per billion) (EPA, 1981). A frequency distribution of hydrogen sulphide concentrations greater than 3.5 ppb (parts per billion) was generated for both monitoring stations.

The odour threshold of 3.5 ppb was exceeded for a total of ten and seven hours, respectively, at the valley and downtown monitoring stations during the monitoring period. As indicated in Figure 3.8, 90% of the winds at the valley station were from the north-northeast during episodes when H_2S concentrations were above the odour threshold. Wind speeds were relatively light during these episodes (less than 15 km/hr). For the remaining 10% of the time the winds were calm at the valley station. At the downtown station, winds were light and from the northwest and north-northwest for the seven hours when the H_2S concentration was above 3.5 ppb.

The concentration at which most individuals can recognize sulphur dioxide in the ambient atmosphere is approximately 0.5 ppm (Leonardos et al. 1969), depending on the individual. Maximum SO_2 concentrations during the monitoring period at the valley and downtown stations were 0.140 and 0.072 ppm, respectively. These concentrations are well below the odour threshold. Because of this observation, SO_2 would not be suspected as causing an odour problem in Fort McMurray.

3.6.2 Odour Complaints

Often, odour complaints in Fort McMurray are reported when hydrogen sulphide and sulphur dioxide concentrations are well below their respective odour thresholds. However, during these times concentrations of other sulphur compounds may be greater than their respective odour thresholds. Other sulphur compounds (thiophenes, carbonyl sulphide, carbon disulphide, ethyl mercaptans and methyl mercaptans) likely contribute to odour events in these situations.

Through the assistance of the Pollution Control Division of Alberta Environment and the Fort McMurray Regional Air Quality Coordinating Committee (RAQCC), odour complaint information for downtown Fort McMurray was obtained from October 1, 1991 to June 30, 1992.

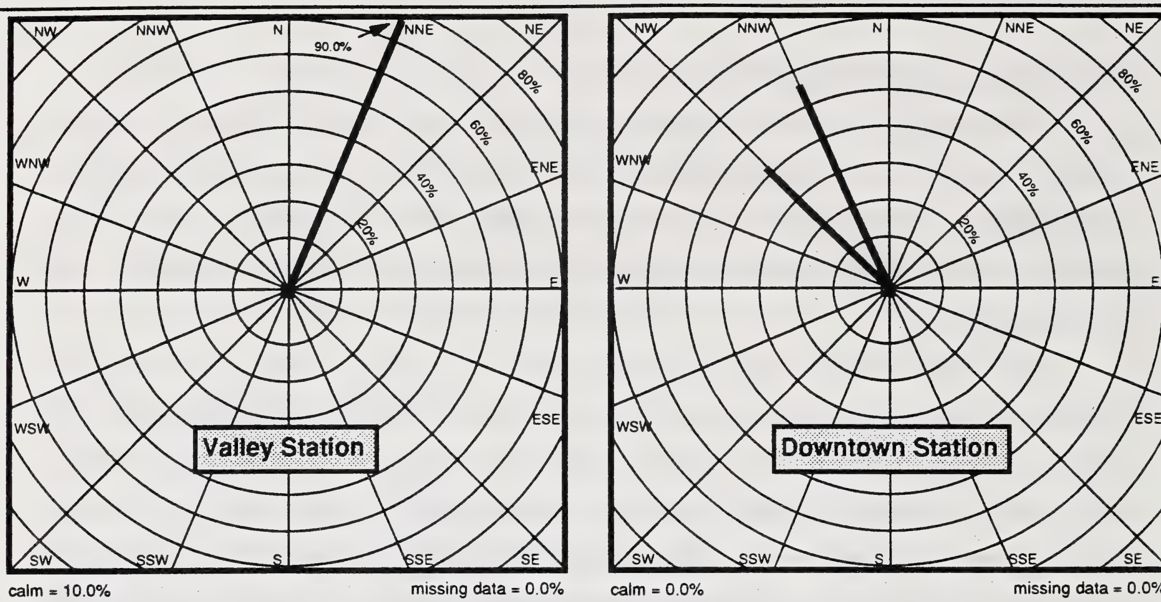

Figure 3.8. Wind direction frequency distribution for times when the 1-hour average hydrogen sulphide concentration was greater than 3.5 ppb .

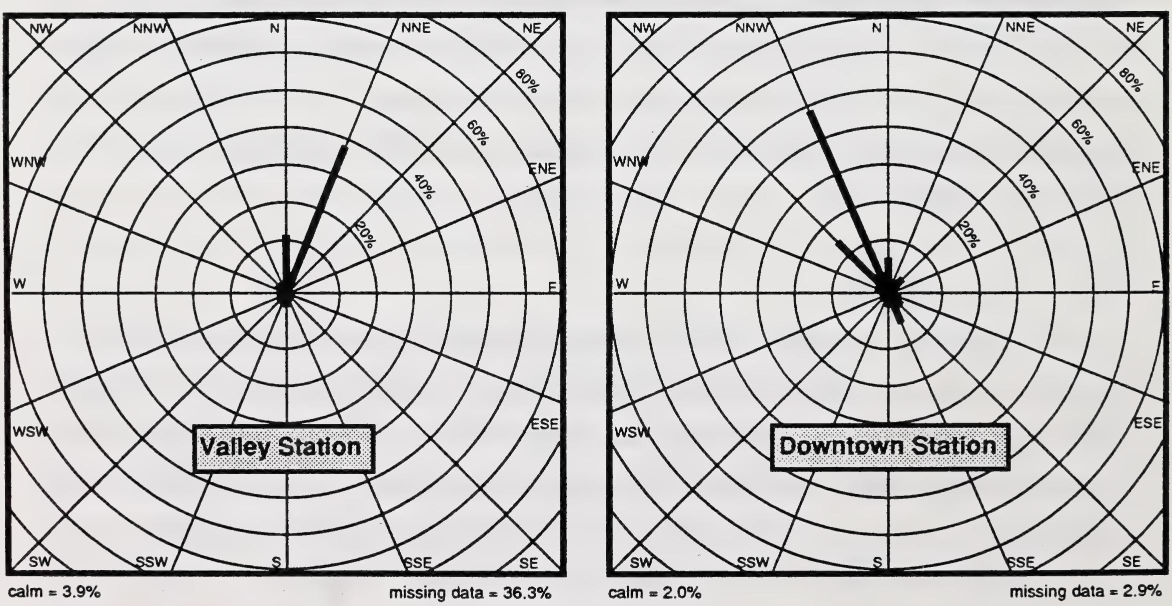

Figure 3.9. Wind direction frequency distribution for times when odour complaints were reported.

Figure 3.4 (page 18) shows the days on which odour complaints were reported overlayed on daily average concentrations of total hydrocarbons, hydrogen sulphide and sulphur dioxide. The number of odour complaints for individual days is presented in Table 3.5.

A total of 129 odour complaints were assessed for the Lower Townsite area during this time period. The highest frequencies of odour complaints were registered from 08:00 to 21:00 LST on December 12, 1991 (21 complaints) and from 16:00 to 21:00 LST on April 27, 1992 (21 complaints). Average H_2S, SO_2 and THC concentrations for times when complaints were recorded are presented in Table 3.6. Concentrations of H_2S and SO_2 were substantially higher at both the valley and downtown station than the average for the monitoring period. Average SO_2 concentrations at the valley and downtown stations were almost 2.5 times higher at times when complaints were recorded than average values for the entire monitoring period. Average H_2S values at the valley and downtown stations were about 3.5 and 1.5 times higher, respectively, than the monitoring period average concentrations. Total hydrocarbon concentrations were only 4% higher during times when complaints were reported than during the average for the entire monitoring period at the valley and downtown stations.

A wind direction frequency distribution for times when odour complaints were recorded is presented in Figure 3.9 (page 30) for the valley and downtown stations. About 50% of winds at the valley station were from the north and north-northeast directions when odour complaints were recorded. Over 40% of the wind speeds at the valley station during complaint times were below 10 km/h. Close to 36% of data at the valley station is unavailable due to instrument malfunction for times when complaints were observed. At the downtown station, almost 66% of winds were from the northwest to north directions when complaints were reported. About 65% of wind speeds were under 10 km/h during complaint times at the downtown station.

Table 3.5. Days on which odour complaints were reported in downtown Fort McMurray.

Day	# of Complaints	Day	# of Complaints	Day	# of Complaints
Oct 2	1	Jan 22	1	Apr 27	21
Oct 16	1	Jan 24	1	Apr 28	1
Oct 20	1	Jan 28	2	May 5	3
Oct 24	1	Feb 1	2	May 6	2
Oct 30	1	Feb 13	1	May 10	1
Nov 4	1	Feb 15	1	May 11	2
Nov 8	1	Feb 18	1	May 14	2
Nov 13	1	Feb 19	1	May 15	1
Nov 26	1	Feb 21	1	May 18	1
Nov 28	1	Feb 25	1	May 27	1
Dec 6	1	Feb 27	1	Jun 2	5
Dec 9	1	Mar 4	1	Jun 5	1
Dec 11	5	Mar 16	1	Jun 7	1
Dec 12	21	Mar 18	1	Jun 8	1
Dec 16	2	Mar 19	3	Jun 10	1
Dec 18	1	Apr 9	1	Jun 16	4
Dec 20	4	Apr 14	1	Jun 17	3
Dec 21	1	Apr 16	1	Jun 24	1
Jan 4	1	Apr 17	1	Jun 25	2
Jan 15	2	Apr 24	1	Jun 30	1
Jan 21	1				

Table 3.6. Average pollutant concentrations for times at which odour complaints were reported versus average pollutant concentrations for the period from October 1, 1991 to June 30, 1992.

Station		SO_2 Concentration (ppm)	H_2S Concentration (ppm)	THC Concentration (ppm)
Valley Station	Monitoring Period Average	0.0031	0.0004	1.710
	Complaint Time Average	0.0075	0.0014	1.776
Downtown Station	Monitoring Period Average	0.0027	0.0005	2.147
	Complaint Time Average	0.0065	0.0008	2.199

4. SUMMARY OF RESULTS

Several different methods have been applied to data collected at the Fort McMurray valley and downtown monitoring stations for the objective of resolving significant differences between these data. For the purposes of discussion, it is useful to designate pollutants as: (1) those that originate from industrial sources; and (2) those that originate from urban sources. A summary of the results of each comparison procedure is indicated in Tables 4.1 and 4.2 for industrial and urban pollutants, respectively.

4.1 Industrial Pollutants

The major sources of H_2S and SO_2 in the Fort McMurray region are the oil sands facilities although, natural sources such as swamps and bogs and urban sources such as vehicles may have a minor contribution to H_2S concentrations.

The monitoring period average concentration of H_2S was slightly higher at the downtown monitoring station. The cumulative frequency distribution for H_2S indicated that concentrations greater than 0.002 ppm occurred more frequently at the valley monitoring station. This result is supported by the occurrence of five exceedances of the 1-hour average regulation for H_2S at the valley station compared to only one exceedance at the downtown station. H_2S concentrations were found to be consistently higher at the valley station by the Wilcoxon signed rank test.

The average SO_2 concentration was 15% higher at the valley station than the downtown station. A higher frequency of SO_2 concentrations greater than 0.001 ppm was observed at the valley station. Statistical tests indicated that concentrations of SO_2 were more likely to be higher at the valley station.

4.2 Urban Pollutants

CO, dust and smoke (COH), and NO_x are pollutants that are primarily emitted by urban sources within the city of Fort McMurray. CO is predominantly emitted as a by-product of inefficient combustion of motor vehicle engines. The major sources of dust and smoke are traffic movement and vehicle exhaust. NO_x (including NO_2 and NO) is present in vehicle exhaust,

Table 4.1 Summary of comparison procedures for pollutants that are primarily emitted by industrial sources.

Pollutant	Daily Average Concentration	Cumulative Frequency Distribution	Sign Test	Wilcoxon Signed Rank Test	Exceedances
Hydrogen Sulphide	Higher peak values at valley station.	Higher frequency of values > 0.002 ppm at valley station.	Higher at downtown station.	Higher at valley station.	More exceedances at valley station.
Sulphur Dioxide	Higher most of the time at valley station.	Higher frequency of values > 0.001 ppm at valley station.	Higher at valley station.	Higher at valley station.	no exceedances

Table 4.2 Summary of comparison procedures for pollutants that are primarily emitted by urban sources.

Pollutant	Daily Average Concentration	Cumulative Frequency Distribution	Sign Test	Wilcoxon Signed Rank Test	Exceedances
Carbon Monoxide	Higher most of the time at downtown station.	Higher frequency of values > 0.3 ppm at downtown station.	Higher at downtown station.	Higher at downtown station.	no exceedances
Coefficient of Haze	Higher most of the time at downtown station.	Higher frequency of values > 0.1 COH units at downtown station.	Higher at downtown station.	Higher at downtown station.	no exceedances
Nitrogen Dioxide	Slightly higher at downtown station.	Frequency distributions are very close.	Higher at downtown station.	Higher at valley station.	no exceedances
Nitric oxide	Slightly higher at downtown station.	Frequency distributions are very close.	Higher at downtown station.	Higher at downtown station.	no regulation
Oxides of Nitrogen	Slightly higher at downtown station.	Frequency distributions are very close.	Higher at downtown station.	Higher at valley station.	no regulation
Ozone	Slightly higher most of the time at downtown station.	Slightly higher frequency at downtown station for all values.	Higher at downtown station.	Higher at downtown station.	More exceedances at downtown station.
Total Hydrocarbons	Higher almost all the time at downtown station.	Higher frequency at downtown station for all values.	Higher at downtown station.	Higher at downtown station.	no regulation

aircraft engine exhaust, emissions from light industry in the area, heating fuel combustion and also a portion may be produced by the oil sands operations.

O_3 is primarily produced by the reaction of sunlight with man-made and naturally occurring oxides of nitrogen and hydrocarbons. Another significant source is the transport of O_3 from the upper troposphere to ground level. The majority of O_3 in the Fort McMurray region is likely generated by natural background sources (Angle and Sandhu 1986) although, a portion of the O_3 may result from emissions of oxides of nitrogen and hydrocarbons from motor vehicles or industrial sources.

Within the city limits of Fort McMurray, most ambient hydrocarbons are produced by urban sources such as vehicular emissions and industrial sources. Lower concentrations of hydrocarbons may also be transported down the Athabasca River valley from the oil sands facilities to the north of the city. Significant quantities of hydrocarbons are also generated by trees and vegetation.

Concentrations of urban pollutants such as CO, COH and THC were substantially higher at the downtown monitoring station. Average values for the monitoring period were 31%, 40% and 26% higher at the downtown station than at the valley station. However, maximum values for these pollutants were relatively low in comparison with Alberta Environment regulations.

NO_2, NO and NO_x concentrations are, on average, higher at the downtown station however, this difference is relatively small. The period averages for NO_2, NO and NO_x were only 5%, 13% and 13% greater at the downtown station. Concentrations of these pollutants were found to be consistently higher at the downtown station using the sign test while NO_2 and NO_x values were found to be significantly higher at the valley station using the Wilcoxon signed rank test.

Average concentrations of O_3 were found to be 10% higher at the downtown monitoring station. According to statistical tests, 1-hour average O_3 concentrations were more likely to be higher at the downtown station than at the valley station. The cumulative frequency distribution for O_3 indicated that there was a consistently higher frequency of O_3 concentrations for all frequencies at the downtown station. Exceedances of the 24-hour average regulation for O_3 were also more frequent at the downtown station.

4.3 Odourous Pollutants

Compounds such as hydrogen sulphide and other sulphur-compounds may be odourous at levels observed in Fort McMurray during the monitoring period. H_2S concentrations greater than 3.5 ppb as a 1-hour average are considered detectable as an odour by some individuals. Sulphur compounds such as carbonyl sulphide, carbon disulphide, thiophenes, ethyl mercaptans and methyl mercaptans were not measured directly at the monitoring stations but, likely contribute to odour episodes in the Fort McMurray region.

Concentrations of H_2S greater than 3.5 ppb occurred more frequently at the valley station then the downtown station. Wind directions during elevated H_2S episodes were from the north-northeast direction at the valley station and from the northwest and north-northwest directions at the downtown station.

A total of 129 odour complaints were available for analysis during the monitoring period. Winds were predominantly from the north and north-northeast directions at the valley station and from the northwest to north directions at the downtown station when odour complaints were recorded. Average concentrations of SO_2 and H_2S at both monitoring stations were substantially higher during odour events than during the remainder of the monitoring period. Average THC concentrations were only 4% higher during odour events at the valley and downtown stations. Average SO_2 and H_2S concentrations at the valley station were 15 and 75% higher, respectively, than those concentrations at the downtown station during times when odour complaints were recorded.

5. OBSERVATIONS AND CONCLUSIONS

The following observations are evident after review of air quality data collected at the valley and downtown stations for the nine month period from October 1, 1991 to June 30, 1992.

- Episodes of elevated sulphur dioxide and hydrogen sulphide concentrations were more frequent at the valley station. Exceedances of the 1-hour regulation for hydrogen sulphide of 0.01 ppm were recorded five times at the valley station compared to one time at the downtown station. The 1-hour regulation for sulphur dioxide of 0.17 ppm was not exceeded at either monitoring station although, the average sulphur dioxide concentration was 15% higher at the valley station.

- Hydrogen sulphide concentrations greater than the odour threshold of 3.5 ppb occurred ten times at the valley station compared to seven times at the downtown station. Average hydrogen sulphide and sulphur dioxide concentrations were substantially higher at the valley station during times when odour complaints were reported by the public. Wind directions during odour events were predominantly from the north to north-northeast at the valley station and from the northwest to north at the downtown stations during times when odours were reported.

- Concentrations of pollutants which are primarily emitted by urban sources, such as automobile emissions and traffic movement, recorded relatively low values at both stations compared to Alberta Environment regulations. Maximum 1-hour average carbon monoxide readings were 38% and 67% of the 1-hour regulation of 13 ppm at the valley and downtown stations, respectively. Coefficient of haze (dust and smoke) values were also well below the monthly regulation (90% of values per month shall be less than 1.0 COH units) at both stations. On average, values of carbon monoxide, the coefficient of haze, and total hydrocarbons were greater at the downtown monitoring station however, as mentioned earlier maximum concentrations of urban pollutants at both locations are below established regulations. Peak 1-hour nitrogen dioxide concentrations of 0.070 and

0.069 ppm which were observed at the valley and downtown stations, respectively, were substantially lower than the 1-hour regulation of 0.210 ppm. Oxides of nitrogen (including nitrogen dioxide and nitric oxide) showed comparable concentrations at both monitoring locations.

- Average ozone values were slightly higher at the downtown station. The 1-hour regulation for ozone of 0.082 ppm was not exceeded at either station however, the 24-hour regulation for ozone of 0.025 ppm was exceeded on 110 and 95 days, respectively, at the downtown and valley stations. Ozone in the Fort McMurray region is likely the result of natural ozone generating processes.

The primary objective of air quality monitoring by Alberta Environment in Fort McMurray is to monitor air pollutants that are transported into Fort McMurray from industrial facilities located to the north of the city. A secondary objective is to monitor air quality that is representative of the urban environment. From the data collected during this study, it is apparent that the valley location is the most suitable location for addressing the primary objective. The valley station is clearly more representative for detecting odour episodes which result from the oil sands facilities. Since concentrations of urban pollutants are relatively low at both stations when compared to Alberta Environment regulations, either location would be adequate for monitoring the urban environment. Both of these objectives are addressed by monitoring air quality, on a permanent basis, at the valley site.

The re-establishment of a permanent air quality station at the valley site is also supported by two additional factors: (1) local pollutant sources (i.e parking lots, bulk fuel storage facilities, sewage lagoons, and oiled roads) are not located near the valley station and, therefore, will not influence air quality readings; and (2) future development in the vicinity of the valley station is not anticipated in the foreseeable future. Air quality data collected at the valley site adequately represents urban air quality while also detecting air quality episodes associated with industrial activities to the north of Fort McMurray.

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7. APPENDICES

7.1 Summary of Data from Valley Monitoring Station

Wind Summary for 1991-92

Fort McMurray Valley Monitoring Station

Joint Wind Direction and Speed Frequency Distribution (no. of hours)

Wind Speed (km/h)

Dir	0-5	5-10	10-15	15-20	20-25	25-30	30-35	35-40	>40	TOTAL
N	72	99	102	39	6	5	0	0	0	323
NNE	148	205	185	81	23	4	0	0	0	646
NE	35	16	14	2	0	0	0	0	0	67
ENE	17	5	1	0	0	0	0	0	0	23
E	40	14	0	0	0	0	0	0	0	54
ESE	28	2	0	0	0	0	0	0	0	30
SE	83	34	3	0	0	0	0	0	0	120
SSE	344	231	41	1	2	3	0	0	0	622
S	229	120	13	3	1	0	0	0	0	366
SSW	37	3	1	0	0	0	0	0	0	41
SW	34	5	0	0	0	0	0	0	0	39
WSW	52	16	4	0	0	0	0	0	0	72
W	101	38	47	23	3	0	0	0	0	212
WNW	63	28	39	17	15	11	1	0	0	174
NW	64	25	23	30	14	9	10	1	0	176
NNW	48	27	26	16	16	8	1	3	0	145
TOTAL	1395	868	499	212	80	40	12	4	0	3110

CALM = 1059 hours

MISSING DATA = 2407 hours

Joint Wind Direction and Speed Frequency Distribution (percent)

Wind Speed (km/h)

Dir	0-5	5-10	10-15	15-20	20-25	25-30	30-35	35-40	>40	TOTAL
N	1.1	1.5	1.6	.6	.1	.1	.0	.0	.0	4.9
NNE	2.3	3.1	2.8	1.2	.3	.1	.0	.0	.0	9.8
NE	.5	.2	.2	.0	.0	.0	.0	.0	.0	1.0
ENE	.3	.1	.0	.0	.0	.0	.0	.0	.0	.3
E	.6	.2	.0	.0	.0	.0	.0	.0	.0	.8
ESE	.4	.0	.0	.0	.0	.0	.0	.0	.0	.5
SE	1.3	.5	.0	.0	.0	.0	.0	.0	.0	1.8
SSE	5.2	3.5	.6	.0	.0	.0	.0	.0	.0	9.5
S	3.5	1.8	.2	.0	.0	.0	.0	.0	.0	5.6
SSW	.6	.0	.0	.0	.0	.0	.0	.0	.0	.6
SW	.5	.1	.0	.0	.0	.0	.0	.0	.0	.6
WSW	.8	.2	.1	.0	.0	.0	.0	.0	.0	1.1
W	1.5	.6	.7	.3	.0	.0	.0	.0	.0	3.2
WNW	1.0	.4	.6	.3	.2	.2	.0	.0	.0	2.6
NW	1.0	.4	.3	.5	.2	.1	.2	.0	.0	2.7
NNW	.7	.4	.4	.2	.2	.1	.0	.0	.0	2.2
TOTAL	21.2	13.2	7.6	3.2	1.2	.6	.2	.1	.0	47.3

CALM = 16.10%

MISSING DATA = 36.60%

CO Summary Statistics for 1991-92
Fort McMurray Valley Monitoring Station
Units are PPM (parts per million)

Ambient 1-hour average regulation = 13.0 PPM
Ambient 8-hour average regulation = 5.0 PPM

BY SEASON

SEASON	MIN	1%	5%	10%	25%	50%	75%	90%	95%	99%	MAX
Winter	.0	.0	.0	.3	.4	.5	.7	1.0	1.6	3.1	5.0
Spring	.0	.2	.2	.2	.3	.3	.4	.6	.8	1.5	2.6
Summer	.2	.2	.2	.2	.3	.3	.4	.5	.6	.9	1.8
Autumn	.1	.1	.2	.3	.3	.4	.6	.8	1.0	1.7	3.4

SEASON	Arithmetic Mean	Geometric Mean	Arithmetic Std Dev	Range	N	Number of Exceedances 1 hour	Number of Exceedances 8 hour
Winter	.611	.325	.556	5.0	2089	0(0.00%)	0(0.00%)
Spring	.393	.347	.242	2.6	1999	0(0.00%)	0(0.00%)
Summer	.350	.325	.153	1.6	718	0(0.00%)	0(0.00%)
Autumn	.476	.410	.325	3.3	1461	0(0.00%)	0(0.00%)

BY MONTH

MONTH	MIN	1%	5%	10%	25%	50%	75%	90%	95%	99%	MAX
Jan(1992)	.0	.0	.0	.0	.3	.5	.8	1.5	2.1	3.5	5.0
Feb(1992)	.2	.3	.3	.3	.4	.5	.7	1.0	1.6	3.4	4.4
Mar(1992)	.0	.2	.2	.2	.3	.4	.5	.8	1.1	2.1	2.5
Apr(1992)	.0	.2	.2	.2	.3	.3	.4	.5	.7	1.3	2.6
May(1992)	.2	.2	.2	.2	.3	.3	.4	.5	.7	1.2	1.5
Jun(1992)	.2	.2	.2	.2	.3	.3	.4	.5	.6	.9	1.8
Jul	*	*	*	*	*	*	*	*	*	*	*
Aug	*	*	*	*	*	*	*	*	*	*	*
Sep	*	*	*	*	*	*	*	*	*	*	*
Oct(1991)	.2	.2	.2	.2	.3	.3	.5	.7	1.0	1.5	2.1
Nov(1991)	.1	.1	.3	.3	.3	.4	.6	.9	1.0	2.5	3.4
Dec(1991)	.0	.0	.0	.3	.3	.5	.6	1.0	1.0	2.3	3.1

MONTH	Arithmetic Mean	Geometric Mean	Arithmetic Std Dev	Range	N	Number of Exceedances 1 hour	Number of Exceedances 8 hour
Jan(1992)	.667	.191	.695	5.0	742	0(0.00%)	0(0.00%)
Feb(1992)	.639	.545	.512	4.2	695	0(0.00%)	0(0.00%)
Mar(1992)	.477	.400	.327	2.5	538	0(0.00%)	0(0.00%)
Apr(1992)	.370	.333	.204	2.6	719	0(0.00%)	0(0.00%)
May(1992)	.355	.325	.183	1.3	742	0(0.00%)	0(0.00%)
Jun(1992)	.350	.325	.153	1.6	718	0(0.00%)	0(0.00%)
Jul	*	*	*	*	*	*	
Aug	*	*	*	*	*	*	
Sep	*	*	*	*	*	*	
Oct(1991)	.433	.379	.269	1.9	742	0(0.00%)	0(0.00%)
Nov(1991)	.521	.445	.370	3.3	719	0(0.00%)	0(0.00%)
Dec(1991)	.517	.321	.386	3.1	652	0(0.00%)	0(0.00%)

BY YEAR

YEAR	MIN	1%	5%	10%	25%	50%	75%	90%	95%	99%	MAX
1991-92	.0	.0	.2	.2	.3	.4	.5	.8	1.1	2.4	5.0

YEAR	Arithmetic Mean	Geometric Mean	Arithmetic Std Dev	Range	N	Number of Exceedances 1 hour	Number of Exceedances 8 hour
1991-92	.479	.245	.400	5.0	6267	0(0.00%)	0(0.00%)

n/a - not applicable   * - no data

COH Summary Statistics for 1991-92
Fort McMurray Valley Monitoring Station
Units are COH units

Ambient regulation = 90% of values per month < 1.0 COH unit

BY SEASON

SEASON	MIN	1%	5%	10%	25%	50%	75%	90%	95%	99%	MAX
Winter	.0	.0	.0	.0	.0	.0	.1	.2	.3	.6	1.0
Spring	.0	.0	.0	.0	.0	.0	.1	.1	.1	.3	.6
Summer	.0	.0	.0	.0	.0	.1	.1	.1	.2	.3	.4
Autumn	.0	.0	.0	.0	.0	.0	.1	.1	.2	.3	.5

SEASON	Arithmetic Mean	Geometric Mean	Arithmetic Std Dev	Range	N	Number of Values > 1.0 COH unit
Winter	.079	.002	.123	1.0	1743	0(0.00%)
Spring	.039	.001	.059	.6	2005	0(0.00%)
Summer	.075	.025	.055	.4	686	0(0.00%)
Autumn	.038	.000	.064	.5	1362	0(0.00%)

BY MONTH

MONTH	MIN	1%	5%	10%	25%	50%	75%	90%	95%	99%	MAX
Jan(1992)	.0	.0	.0	.0	.0	.0	.1	.3	.4	.6	.8
Feb(1992)	.0	.0	.0	.0	.0	.1	.1	.2	.3	.8	1.0
Mar(1992)	.0	.0	.0	.0	.0	.0	.0	.1	.2	.5	.6
Apr(1992)	.0	.0	.0	.0	.0	.0	.0	.1	.1	.2	.4
May(1992)	.0	.0	.0	.0	.0	.0	.1	.1	.1	.2	.4
Jun(1992)	.0	.0	.0	.0	.0	.1	.1	.1	.2	.3	.4
Jul	*	*	*	*	*	*	*	*	*	*	*
Aug	*	*	*	*	*	*	*	*	*	*	*
Sep	*	*	*	*	*	*	*	*	*	*	*
Oct(1991)	.0	.0	.0	.0	.0	.0	.0	.1	.1	.3	.5
Nov(1991)	.0	.0	.0	.0	.0	.0	.1	.1	.2	.3	.5
Dec(1991)	.0	.0	.0	.0	.0	.0	.1	.2	.2	.4	.8

MONTH	Arithmetic Mean	Geometric Mean	Arithmetic Std Dev	Range	N	Number of Values > 1.0 COH unit
Jan(1992)	.091	.001	.139	.8	503	0(0.00%)
Feb(1992)	.089	.008	.128	1.0	653	0(0.00%)
Mar(1992)	.037	.000	.080	.6	542	0(0.00%)
Apr(1992)	.030	.000	.045	.4	720	0(0.00%)
May(1992)	.054	.007	.052	.4	743	0(0.00%)
Jun(1992)	.075	.025	.055	.4	686	0(0.00%)
Jul	*	*	*	*	*	*
Aug	*	*	*	*	*	*
Sep	*	*	*	*	*	*
Oct(1991)	.033	.000	.057	.5	677	0(0.00%)
Nov(1991)	.044	.001	.070	.5	685	0(0.00%)
Dec(1991)	.057	.001	.095	.8	587	0(0.00%)

BY YEAR

YEAR	MIN	1%	5%	10%	25%	50%	75%	90%	95%	99%	MAX
1991-92	.0	.0	.0	.0	.0	.0	.1	.1	.2	.4	1.0

YEAR	Arithmetic Mean	Geometric Mean	Arithmetic Std Dev	Range	N	Number of Values > 1.0 COH unit
1991-92	.054	.001	.086	1.0	5796	0(0.00%)

n/a - not applicable * - no data

H2S Summary Statistics for 1991-92
Fort McMurray Valley Monitoring Station
Units are PPM (parts per million)

Ambient 1-hour average regulation = .010 PPM
Ambient 24-hour average regulation = .003 PPM

BY SEASON

SEASON	MIN	1%	5%	10%	25%	50%	75%	90%	95%	99%	MAX
Winter	.000	.000	.000	.000	.000	.000	.001	.001	.002	.003	.017
Spring	.000	.000	.000	.000	.000	.000	.001	.001	.001	.001	.003
Summer	.000	.000	.000	.000	.000	.000	.000	.000	.001	.001	.001
Autumn	.000	.000	.000	.000	.000	.000	.000	.001	.001	.003	.003

SEASON	Arithmetic Mean	Geometric Mean	Arithmetic Std Dev	Range	N	Number of Exceedances 1 hour	24 hour
Winter	.0006	.0001	.0009	.017	2147	5(0.23%)	0(0.00%)
Spring	.0004	.0001	.0004	.003	1998	0(0.00%)	0(0.00%)
Summer	.0001	.0000	.0003	.001	717	0(0.00%)	0(0.00%)
Autumn	.0003	.0000	.0006	.003	1461	0(0.00%)	0(0.00%)

BY MONTH

MONTH	MIN	1%	5%	10%	25%	50%	75%	90%	95%	99%	MAX
Jan(1992)	.000	.000	.000	.000	.000	.001	.001	.001	.001	.003	.003
Feb(1992)	.000	.000	.000	.000	.000	.001	.001	.001	.001	.002	.004
Mar(1992)	.000	.000	.000	.000	.000	.001	.001	.001	.001	.001	.002
Apr(1992)	.000	.000	.000	.000	.000	.000	.001	.001	.001	.001	.003
May(1992)	.000	.000	.000	.000	.000	.000	.001	.001	.001	.001	.002
Jun(1992)	.000	.000	.000	.000	.000	.000	.000	.000	.001	.001	.001
Jul	*	*	*	*	*	*	*	*	*	*	*
Aug	*	*	*	*	*	*	*	*	*	*	*
Sep	*	*	*	*	*	*	*	*	*	*	*
Oct(1991)	.000	.000	.000	.000	.000	.001	.001	.001	.001	.001	.002
Nov(1991)	.000	.000	.000	.000	.000	.000	.001	.001	.002	.003	.003
Dec(1991)	.000	.000	.000	.000	.000	.000	.001	.001	.002	.007	.017

MONTH	Arithmetic Mean	Geometric Mean	Arithmetic Std Dev	Range	N	Number of Exceedances 1 hour	24 hour
Jan(1992)	.0006	.0001	.0005	.003	740	0(0.00%)	0(0.00%)
Feb(1992)	.0007	.0003	.0005	.004	695	0(0.00%)	0(0.00%)
Mar(1992)	.0005	.0001	.0004	.002	540	0(0.00%)	0(0.00%)
Apr(1992)	.0003	.0000	.0004	.003	714	0(0.00%)	0(0.00%)
May(1992)	.0004	.0001	.0004	.002	744	0(0.00%)	0(0.00%)
Jun(1992)	.0001	.0000	.0003	.001	717	0(0.00%)	0(0.00%)
Jul	*	*	*	*	*	*	
Aug	*	*	*	*	*	*	
Sep	*	*	*	*	*	*	
Oct(1991)	.0005	.0001	.0004	.002	741	0(0.00%)	0(0.00%)
Nov(1991)	.0005	.0000	.0007	.003	720	0(0.00%)	0(0.00%)
Dec(1991)	.0005	.0000	.0014	.017	712	5(0.70%)	0(0.00%)

BY YEAR

YEAR	MIN	1%	5%	10%	25%	50%	75%	90%	95%	99%	MAX
1991-92	.000	.000	.000	.000	.000	.000	.001	.001	.001	.002	.017

YEAR	Arithmetic Mean	Geometric Mean	Arithmetic Std Dev	Range	N	Number of Exceedances 1 hour	24 hour
1991-92	.0004	.0000	.0006	.017	6323	5(0.70%)	0(0.00%)

n/a - not applicable   * - no data

Wind Summary for 1991-92
Fort McMurray Valley Monitoring Station
** calculation is for exceedances of the 1-hour regulation for H2S **

Joint Wind Direction and Speed Frequency Distribution (no. of hours)

	Wind Speed (km/h)									
Dir	0-5	5-10	10-15	15-20	20-25	25-30	30-35	35-40	>40	TOTAL
N	0	0	0	0	0	0	0	0	0	0
NNE	3	2	0	0	0	0	0	0	0	5
NE	0	0	0	0	0	0	0	0	0	0
ENE	0	0	0	0	0	0	0	0	0	0
E	0	0	0	0	0	0	0	0	0	0
ESE	0	0	0	0	0	0	0	0	0	0
SE	0	0	0	0	0	0	0	0	0	0
SSE	0	0	0	0	0	0	0	0	0	0
S	0	0	0	0	0	0	0	0	0	0
SSW	0	0	0	0	0	0	0	0	0	0
SW	0	0	0	0	0	0	0	0	0	0
WSW	0	0	0	0	0	0	0	0	0	0
W	0	0	0	0	0	0	0	0	0	0
WNW	0	0	0	0	0	0	0	0	0	0
NW	0	0	0	0	0	0	0	0	0	0
NNW	0	0	0	0	0	0	0	0	0	0
TOTAL	3	2	0	0	0	0	0	0	0	5

CALM = 0 hours
MISSING DATA = 0 hours

Joint Wind Direction and Speed Frequency Distribution (percent)

	Wind Speed (km/h)									
Dir	0-5	5-10	10-15	15-20	20-25	25-30	30-35	35-40	>40	TOTAL
N	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
NNE	60.0	40.0	.0	.0	.0	.0	.0	.0	.0	100.0
NE	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
ENE	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
E	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
ESE	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
SE	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
SSE	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
S	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
SSW	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
SW	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
WSW	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
W	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
WNW	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
NW	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
NNW	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
TOTAL	60.0	40.0	.0	.0	.0	.0	.0	.0	.0	100.0

CALM = .00%
MISSING DATA = .00%

NO2 Summary Statistics for 1991-92
Fort McMurray Valley Monitoring Station
Units are PPM (parts per million)

Ambient 1-hour average regulation = .210 PPM
Ambient 24-hour average regulation = .110 PPM
Ambient annual average regulation = .030 PPM

BY SEASON

SEASON	MIN	1%	5%	10%	25%	50%	75%	90%	95%	99%	MAX
Winter	.000	.000	.002	.003	.007	.012	.020	.030	.035	.051	.070
Spring	.000	.001	.001	.001	.002	.005	.010	.019	.026	.040	.064
Summer	.000	.000	.001	.001	.002	.003	.006	.010	.013	.021	.024
Autumn	.001	.001	.002	.002	.004	.009	.016	.023	.027	.036	.044

SEASON	Arithmetic Mean	Geometric Mean	Arithmetic Std Dev	Range	N	Number of Exceedances 1 hour	24 hour
Winter	.0150	.0093	.0109	.070	2042	0(0.00%)	0(0.00%)
Spring	.0078	.0046	.0085	.064	1880	0(0.00%)	0(0.00%)
Summer	.0046	.0027	.0041	.024	717	0(0.00%)	0(0.00%)
Autumn	.0110	.0081	.0082	.043	1273	0(0.00%)	0(0.00%)

BY MONTH

MONTH	MIN	1%	5%	10%	25%	50%	75%	90%	95%	99%	MAX
Jan(1992)	.000	.000	.000	.003	.010	.014	.021	.030	.040	.054	.061
Feb(1992)	.001	.001	.002	.002	.005	.012	.021	.031	.038	.057	.070
Mar(1992)	.001	.001	.001	.001	.003	.008	.016	.027	.036	.051	.055
Apr(1992)	.000	.001	.001	.001	.002	.004	.008	.013	.020	.040	.064
May(1992)	.000	.001	.001	.001	.002	.004	.009	.017	.023	.034	.047
Jun(1992)	.000	.000	.001	.001	.002	.003	.006	.010	.013	.021	.024
Jul	*	*	*	*	*	*	*	*	*	*	*
Aug	*	*	*	*	*	*	*	*	*	*	*
Sep	*	*	*	*	*	*	*	*	*	*	*
Oct(1991)	.001	.001	.002	.002	.003	.007	.012	.023	.027	.034	.041
Nov(1991)	.001	.002	.002	.003	.006	.011	.017	.024	.027	.037	.044
Dec(1991)	.000	.002	.003	.005	.008	.011	.020	.028	.030	.040	.047

MONTH	Arithmetic Mean	Geometric Mean	Arithmetic Std Dev	Range	N	Number of Exceedances 1 hour	24 hour
Jan(1992)	.0164	.0083	.0117	.061	639	0(0.00%)	0(0.00%)
Feb(1992)	.0147	.0101	.0119	.069	694	0(0.00%)	0(0.00%)
Mar(1992)	.0115	.0069	.0110	.054	429	0(0.00%)	0(0.00%)
Apr(1992)	.0066	.0042	.0072	.064	711	0(0.00%)	0(0.00%)
May(1992)	.0069	.0040	.0073	.047	740	0(0.00%)	0(0.00%)
Jun(1992)	.0046	.0027	.0041	.024	717	0(0.00%)	0(0.00%)
Jul	*	*	*	*	*	*	
Aug	*	*	*	*	*	*	
Sep	*	*	*	*	*	*	
Oct(1991)	.0094	.0067	.0079	.040	554	0(0.00%)	0(0.00%)
Nov(1991)	.0123	.0095	.0082	.043	719	0(0.00%)	0(0.00%)
Dec(1991)	.0140	.0107	.0087	.047	709	0(0.00%)	0(0.00%)

BY YEAR

YEAR	MIN	1%	5%	10%	25%	50%	75%	90%	95%	99%	MAX
1991-92	.000	.000	.001	.002	.003	.008	.015	.024	.030	.044	.070

YEAR	Arithmetic Mean	Geometric Mean	Arithmetic Std Dev	Range	N	Number of Exceedances 1 hour	24 hour
1991-92	.0106	.0060	.0097	.070	5912	0(0.00%)	0(0.00%)

n/a - not applicable   * - no data

NO Summary Statistics for 1991-92
Fort McMurray Valley Monitoring Station
Units are PPM (parts per million)

No regulations

BY SEASON

SEASON	MIN	1%	5%	10%	25%	50%	75%	90%	95%	99%	MAX
Winter	.000	.000	.000	.000	.000	.005	.016	.045	.080	.187	.334
Spring	.000	.000	.000	.000	.000	.000	.003	.006	.014	.059	.137
Summer	.000	.000	.000	.000	.002	.003	.005	.008	.010	.016	.028
Autumn	.000	.000	.002	.002	.003	.004	.010	.022	.040	.086	.187

SEASON	Arithmetic Mean	Geometric Mean	Arithmetic Std Dev	Range	N	Number of Exceedances
Winter	.0169	.0010	.0333	.334	2054	n/a
Spring	.0033	.0000	.0100	.137	1880	n/a
Summer	.0039	.0016	.0033	.028	717	n/a
Autumn	.0099	.0045	.0160	.187	1273	n/a

BY MONTH

MONTH	MIN	1%	5%	10%	25%	50%	75%	90%	95%	99%	MAX
Jan(1992)	.000	.000	.000	.000	.003	.009	.020	.060	.104	.200	.334
Feb(1992)	.000	.000	.000	.000	.000	.001	.010	.037	.071	.207	.244
Mar(1992)	.000	.000	.000	.000	.000	.000	.002	.016	.041	.096	.137
Apr(1992)	.000	.000	.000	.000	.000	.000	.001	.004	.007	.033	.085
May(1992)	.000	.000	.000	.000	.000	.002	.004	.006	.010	.029	.049
Jun(1992)	.000	.000	.000	.000	.002	.003	.005	.008	.010	.016	.028
Jul	*	*	*	*	*	*	*	*	*	*	*
Aug	*	*	*	*	*	*	*	*	*	*	*
Sep	*	*	*	*	*	*	*	*	*	*	*
Oct(1991)	.001	.002	.002	.002	.002	.004	.008	.019	.035	.074	.090
Nov(1991)	.000	.000	.002	.002	.003	.005	.011	.024	.041	.098	.187
Dec(1991)	.000	.000	.000	.000	.003	.006	.020	.040	.052	.129	.250

MONTH	Arithmetic Mean	Geometric Mean	Arithmetic Std Dev	Range	N	Number of Exceedances
Jan(1992)	.0221	.0026	.0408	.334	651	n/a
Feb(1992)	.0133	.0001	.0328	.244	694	n/a
Mar(1992)	.0061	.0000	.0176	.137	429	n/a
Apr(1992)	.0019	.0000	.0068	.085	711	n/a
May(1992)	.0031	.0004	.0052	.049	740	n/a
Jun(1992)	.0039	.0016	.0033	.028	717	n/a
Jul	*	*	*	*	*	*
Aug	*	*	*	*	*	*
Sep	*	*	*	*	*	*
Oct(1991)	.0086	.0049	.0133	.089	554	n/a
Nov(1991)	.0108	.0048	.0177	.187	719	n/a
Dec(1991)	.0155	.0035	.0245	.250	709	n/a

BY YEAR

YEAR	MIN	1%	5%	10%	25%	50%	75%	90%	95%	99%	MAX
1991-92	.000	.000	.000	.000	.000	.003	.008	.021	.042	.119	.334

YEAR	Arithmetic Mean	Geometric Mean	Arithmetic Std Dev	Range	N	Number of Exceedances
1991-92	.0095	.0006	.0225	.334	5924	n/a

n/a - not applicable   * - no data

NOX Summary Statistics for 1991-92
Fort McMurray Valley Monitoring Station
Units are PPM (parts per million)

No regulations

BY SEASON

SEASON	MIN	1%	5%	10%	25%	50%	75%	90%	95%	99%	MAX
Winter	.000	.000	.000	.002	.007	.017	.033	.070	.111	.231	.372
Spring	.000	.000	.000	.000	.001	.004	.010	.022	.038	.096	.188
Summer	.000	.000	.000	.001	.003	.005	.010	.015	.020	.031	.046
Autumn	.001	.002	.002	.003	.005	.011	.024	.042	.063	.116	.226

SEASON	Arithmetic Mean	Geometric Mean	Arithmetic Std Dev	Range	N	Number of Exceedances
Winter	.0301	.0081	.0423	.372	2054	n/a
Spring	.0094	.0009	.0173	.188	1880	n/a
Summer	.0071	.0027	.0064	.046	717	n/a
Autumn	.0188	.0110	.0227	.225	1273	n/a

BY MONTH

MONTH	MIN	1%	5%	10%	25%	50%	75%	90%	95%	99%	MAX
Jan(1992)	.000	.000	.000	.002	.010	.020	.040	.090	.145	.250	.372
Feb(1992)	.000	.000	.000	.000	.003	.012	.029	.063	.110	.265	.290
Mar(1992)	.000	.000	.000	.000	.000	.006	.016	.042	.074	.146	.188
Apr(1992)	.000	.000	.000	.000	.001	.003	.007	.016	.025	.062	.145
May(1992)	.000	.000	.000	.000	.001	.005	.010	.020	.029	.057	.085
Jun(1992)	.000	.000	.000	.001	.003	.005	.010	.015	.020	.031	.046
Jul	*	*	*	*	*	*	*	*	*	*	*
Aug	*	*	*	*	*	*	*	*	*	*	*
Sep	*	*	*	*	*	*	*	*	*	*	*
Oct(1991)	.001	.001	.002	.002	.004	.009	.019	.039	.059	.105	.128
Nov(1991)	.001	.002	.002	.003	.006	.014	.026	.044	.065	.133	.226
Dec(1991)	.000	.002	.004	.005	.010	.018	.035	.061	.081	.161	.287

MONTH	Arithmetic Mean	Geometric Mean	Arithmetic Std Dev	Range	N	Number of Exceedances
Jan(1992)	.0366	.0102	.0501	.372	651	n/a
Feb(1992)	.0261	.0030	.0432	.290	694	n/a
Mar(1992)	.0157	.0008	.0275	.188	429	n/a
Apr(1992)	.0068	.0007	.0130	.145	711	n/a
May(1992)	.0082	.0011	.0113	.085	740	n/a
Jun(1992)	.0071	.0027	.0064	.046	717	n/a
Jul	*	*	*	*	*	*
Aug	*	*	*	*	*	*
Sep	*	*	*	*	*	*
Oct(1991)	.0160	.0091	.0201	.127	554	n/a
Nov(1991)	.0209	.0127	.0243	.225	719	n/a
Dec(1991)	.0280	.0168	.0314	.287	709	n/a

BY YEAR

YEAR	MIN	1%	5%	10%	25%	50%	75%	90%	95%	99%	MAX
1991-92	.000	.000	.000	.000	.003	.009	.021	.042	.070	.159	.372

YEAR	Arithmetic Mean	Geometric Mean	Arithmetic Std Dev	Range	N	Number of Exceedances
1991-92	.0183	.0036	.0303	.372	5924	n/a

n/a - not applicable   * - no data

O3 Summary Statistics for 1991-92
Fort McMurray Valley Monitoring Station
Units are PPM (parts per million)

Ambient 1-hour average regulation = .080 PPM
Ambient 24-hour average regulation = .025 PPM

BY SEASON

SEASON	MIN	1%	5%	10%	25%	50%	75%	90%	95%	99%	MAX
Winter	.000	.000	.000	.002	.006	.016	.026	.034	.037	.044	.051
Spring	.000	.002	.007	.012	.022	.032	.039	.046	.049	.053	.059
Summer	.000	.001	.004	.006	.011	.017	.030	.037	.041	.049	.051
Autumn	.000	.001	.002	.004	.011	.020	.028	.033	.036	.042	.043

SEASON	Arithmetic Mean	Geometric Mean	Arithmetic Std Dev	Range	N	Number of Exceedances 1 hour	24 hour
Winter	.0170	.0074	.0118	.051	2147	0(0.00%)	16(17.98%)
Spring	.0301	.0249	.0125	.059	1923	0(0.00%)	63(79.75%)
Summer	.0202	.0160	.0117	.051	719	0(0.00%)	4(13.33%)
Autumn	.0195	.0150	.0106	.043	1462	0(0.00%)	12(19.67%)

BY MONTH

MONTH	MIN	1%	5%	10%	25%	50%	75%	90%	95%	99%	MAX
Jan(1992)	.000	.000	.000	.000	.005	.015	.025	.031	.035	.040	.044
Feb(1992)	.000	.001	.001	.002	.010	.020	.030	.035	.038	.049	.051
Mar(1992)	.001	.002	.005	.009	.021	.034	.040	.045	.048	.051	.052
Apr(1992)	.000	.001	.010	.014	.022	.031	.038	.044	.048	.051	.054
May(1992)	.000	.002	.007	.011	.021	.031	.040	.047	.051	.056	.059
Jun(1992)	.000	.001	.004	.006	.011	.017	.030	.037	.041	.049	.051
Jul	*	*	*	*	*	*	*	*	*	*	*
Aug	*	*	*	*	*	*	*	*	*	*	*
Sep	*	*	*	*	*	*	*	*	*	*	*
Oct(1991)	.001	.001	.002	.005	.011	.019	.028	.034	.038	.042	.043
Nov(1991)	.000	.001	.002	.004	.010	.020	.028	.033	.034	.038	.041
Dec(1991)	.000	.000	.000	.003	.005	.013	.024	.032	.040	.044	.045

MONTH	Arithmetic Mean	Geometric Mean	Arithmetic Std Dev	Range	N	Number of Exceedances 1 hour	24 hour
Jan(1992)	.0159	.0052	.0114	.044	740	0(0.00%)	3(9.68%)
Feb(1992)	.0200	.0128	.0122	.051	695	0(0.00%)	10(34.48%)
Mar(1992)	.0302	.0252	.0133	.051	459	0(0.00%)	13(72.22%)
Apr(1992)	.0299	.0251	.0113	.054	720	0(0.00%)	24(80.00%)
May(1992)	.0303	.0244	.0132	.059	744	0(0.00%)	26(83.87%)
Jun(1992)	.0202	.0160	.0117	.051	719	0(0.00%)	4(13.33%)
Jul	*	*	*	*	*	*	
Aug	*	*	*	*	*	*	
Sep	*	*	*	*	*	*	
Oct(1991)	.0198	.0156	.0108	.042	742	0(0.00%)	8(25.81%)
Nov(1991)	.0191	.0145	.0104	.041	720	0(0.00%)	4(13.33%)
Dec(1991)	.0155	.0071	.0115	.045	712	0(0.00%)	3(10.34%)

BY YEAR

YEAR	MIN	1%	5%	10%	25%	50%	75%	90%	95%	99%	MAX
1991-92	.000	.000	.002	.005	.011	.022	.032	.040	.044	.051	.059

YEAR	Arithmetic Mean	Geometric Mean	Arithmetic Std Dev	Range	N	Number of Exceedances 1 hour	24 hour
1991-92	.0220	.0136	.0130	.059	6251	0(0.00%)	95(36.68%)

n/a - not applicable * - no data

Wind Summary for 1991-92
Fort McMurray Valley Monitoring Station
** calculation is for exceedances of the 24-hour regulation for O3 **

Joint Wind Direction and Speed Frequency Distribution (no. of hours)

Dir	0-5	5-10	10-15	15-20	20-25	25-30	30-35	35-40	>40	TOTAL
	Wind Speed (km/h)									
N	24	33	45	20	3	5	0	0	0	130
NNE	48	103	109	49	15	4	0	0	0	328
NE	14	11	10	2	0	0	0	0	0	37
ENE	4	4	1	0	0	0	0	0	0	9
E	11	11	0	0	0	0	0	0	0	22
ESE	16	1	0	0	0	0	0	0	0	17
SE	17	7	2	0	0	0	0	0	0	26
SSE	37	11	16	0	0	0	0	0	0	64
S	28	13	4	0	0	0	0	0	0	45
SSW	6	2	0	0	0	0	0	0	0	8
SW	10	3	0	0	0	0	0	0	0	13
WSW	12	1	1	0	0	0	0	0	0	14
W	26	16	30	18	1	0	0	0	0	91
WNW	25	11	23	15	6	6	1	0	0	87
NW	13	5	11	22	11	5	7	1	0	75
NNW	9	6	18	12	8	4	1	3	0	61
TOTAL	300	238	270	138	44	24	9	4	0	1027

CALM = 176 hours
MISSING DATA = 1077 hours

Joint Wind Direction and Speed Frequency Distribution (percent)

Dir	0-5	5-10	10-15	15-20	20-25	25-30	30-35	35-40	>40	TOTAL
	Wind Speed (km/h)									
N	1.1	1.4	2.0	.9	.1	.2	.0	.0	.0	5.7
NNE	2.1	4.5	4.8	2.1	.7	.2	.0	.0	.0	14.4
NE	.6	.5	.4	.1	.0	.0	.0	.0	.0	1.6
ENE	.2	.2	.0	.0	.0	.0	.0	.0	.0	.4
E	.5	.5	.0	.0	.0	.0	.0	.0	.0	1.0
ESE	.7	.0	.0	.0	.0	.0	.0	.0	.0	.7
SE	.7	.3	.1	.0	.0	.0	.0	.0	.0	1.1
SSE	1.6	.5	.7	.0	.0	.0	.0	.0	.0	2.8
S	1.2	.6	.2	.0	.0	.0	.0	.0	.0	2.0
SSW	.3	.1	.0	.0	.0	.0	.0	.0	.0	.4
SW	.4	.1	.0	.0	.0	.0	.0	.0	.0	.6
WSW	.5	.0	.0	.0	.0	.0	.0	.0	.0	.6
W	1.1	.7	1.3	.8	.0	.0	.0	.0	.0	4.0
WNW	1.1	.5	1.0	.7	.3	.3	.0	.0	.0	3.8
NW	.6	.2	.5	1.0	.5	.2	.3	.0	.0	3.3
NNW	.4	.3	.8	.5	.4	.2	.0	.1	.0	2.7
TOTAL	13.2	10.4	11.8	6.1	1.9	1.1	.4	.2	.0	45.0

CALM = 7.72%
MISSING DATA = 47.24%

SO2 Summary Statistics for 1991-92
Fort McMurray Valley Monitoring Station
Units are PPM (parts per million)

Ambient 1-hour average regulation = .170 PPM
Ambient 24-hour average regulation = .060 PPM
Ambient annual average regulation = .010 PPM

BY SEASON

SEASON	MIN	1%	5%	10%	25%	50%	75%	90%	95%	99%	MAX
Winter	.000	.000	.000	.000	.001	.003	.005	.010	.017	.039	.140
Spring	.000	.000	.000	.000	.000	.000	.002	.005	.012	.032	.096
Summer	.000	.000	.000	.000	.000	.000	.001	.004	.010	.021	.034
Autumn	.000	.000	.000	.000	.001	.002	.002	.005	.011	.026	.056

SEASON	Arithmetic Mean	Geometric Mean	Arithmetic Std Dev	Range	N	Number of Exceedances 1 hour	24 hour
Winter	.0046	.0009	.0076	.140	2088	0(0.00%)	0(0.00%)
Spring	.0023	.0000	.0061	.096	1996	0(0.00%)	0(0.00%)
Summer	.0015	.0000	.0041	.034	717	0(0.00%)	0(0.00%)
Autumn	.0028	.0010	.0047	.056	1459	0(0.00%)	0(0.00%)

BY MONTH

MONTH	MIN	1%	5%	10%	25%	50%	75%	90%	95%	99%	MAX
Jan(1992)	.000	.000	.000	.000	.000	.002	.004	.010	.020	.040	.060
Feb(1992)	.001	.001	.002	.002	.003	.004	.007	.012	.019	.043	.140
Mar(1992)	.000	.000	.000	.000	.001	.002	.003	.014	.023	.053	.096
Apr(1992)	.000	.000	.000	.000	.000	.000	.001	.004	.010	.025	.037
May(1992)	.000	.000	.000	.000	.000	.000	.000	.002	.006	.013	.021
Jun(1992)	.000	.000	.000	.000	.000	.000	.001	.004	.010	.021	.034
Jul	*	*	*	*	*	*	*	*	*	*	*
Aug	*	*	*	*	*	*	*	*	*	*	*
Sep	*	*	*	*	*	*	*	*	*	*	*
Oct(1991)	.000	.000	.000	.000	.001	.001	.002	.004	.006	.022	.056
Nov(1991)	.000	.001	.001	.001	.001	.002	.003	.008	.014	.029	.042
Dec(1991)	.000	.000	.000	.000	.000	.002	.003	.009	.012	.030	.081

MONTH	Arithmetic Mean	Geometric Mean	Arithmetic Std Dev	Range	N	Number of Exceedances 1 hour	24 hour
Jan(1992)	.0040	.0004	.0071	.060	681	0(0.00%)	0(0.00%)
Feb(1992)	.0065	.0045	.0089	.139	695	0(0.00%)	0(0.00%)
Mar(1992)	.0050	.0013	.0097	.096	536	0(0.00%)	0(0.00%)
Apr(1992)	.0017	.0000	.0044	.037	716	0(0.00%)	0(0.00%)
May(1992)	.0009	.0000	.0025	.021	744	0(0.00%)	0(0.00%)
Jun(1992)	.0015	.0000	.0041	.034	717	0(0.00%)	0(0.00%)
Jul	*	*	*	*	*	*	
Aug	*	*	*	*	*	*	
Sep	*	*	*	*	*	*	
Oct(1991)	.0020	.0005	.0041	.056	739	0(0.00%)	0(0.00%)
Nov(1991)	.0036	.0022	.0051	.042	720	0(0.00%)	0(0.00%)
Dec(1991)	.0035	.0004	.0061	.081	712	0(0.00%)	0(0.00%)

BY YEAR

YEAR	MIN	1%	5%	10%	25%	50%	75%	90%	95%	99%	MAX
1991-92	.000	.000	.000	.000	.000	.001	.003	.008	.013	.032	.140

YEAR	Arithmetic Mean	Geometric Mean	Arithmetic Std Dev	Range	N	Number of Exceedances 1 hour	24 hour
1991-92	.0031	.0002	.0063	.140	6260	0(0.00%)	0(0.00%)

n/a - not applicable * - no data

THC Summary Statistics for 1991-92
Fort McMurray Valley Monitoring Station
Units are PPM (parts per million)

No regulations

BY SEASON

SEASON	MIN	1%	5%	10%	25%	50%	75%	90%	95%	99%	MAX
Winter	1.2	1.3	1.4	1.5	1.6	1.8	1.9	2.1	2.2	2.7	3.4
Spring	1.1	1.2	1.4	1.4	1.5	1.7	1.8	1.9	2.0	2.2	2.6
Summer	1.3	1.3	1.4	1.4	1.5	1.6	1.7	1.8	1.9	2.1	2.2
Autumn	.6	1.3	1.4	1.5	1.6	1.6	1.8	2.0	2.1	2.5	3.2

SEASON	Arithmetic Mean	Geometric Mean	Arithmetic Std Dev	Range	N	Number of Exceedances
Winter	1.781	1.763	.258	2.2	2143	n/a
Spring	1.667	1.655	.199	1.5	1999	n/a
Summer	1.636	1.628	.165	.9	720	n/a
Autumn	1.699	1.685	.235	2.6	1460	n/a

BY MONTH

MONTH	MIN	1%	5%	10%	25%	50%	75%	90%	95%	99%	MAX
Jan(1992)	1.2	1.3	1.3	1.5	1.7	1.8	1.9	2.1	2.2	2.6	3.1
Feb(1992)	1.3	1.4	1.5	1.5	1.7	1.9	2.0	2.2	2.3	2.9	3.4
Mar(1992)	1.2	1.5	1.6	1.7	1.8	1.9	1.9	2.0	2.1	2.3	2.6
Apr(1992)	1.1	1.1	1.3	1.4	1.5	1.6	1.7	1.8	1.9	2.1	2.4
May(1992)	1.3	1.3	1.4	1.4	1.5	1.6	1.7	1.8	1.8	2.0	2.1
Jun(1992)	1.3	1.3	1.4	1.4	1.5	1.6	1.7	1.8	1.9	2.1	2.2
Jul	*	*	*	*	*	*	*	*	*	*	*
Aug	*	*	*	*	*	*	*	*	*	*	*
Sep	*	*	*	*	*	*	*	*	*	*	*
Oct(1991)	.6	1.2	1.4	1.5	1.6	1.7	1.9	2.1	2.2	2.9	3.2
Nov(1991)	1.4	1.4	1.5	1.5	1.5	1.6	1.7	1.8	1.8	2.2	2.3
Dec(1991)	1.2	1.3	1.4	1.5	1.6	1.7	1.8	1.9	2.0	2.4	3.4

MONTH	Arithmetic Mean	Geometric Mean	Arithmetic Std Dev	Range	N	Number of Exceedances
Jan(1992)	1.789	1.772	.255	1.9	741	n/a
Feb(1992)	1.856	1.837	.277	2.1	693	n/a
Mar(1992)	1.845	1.838	.155	1.4	537	n/a
Apr(1992)	1.626	1.615	.190	1.3	718	n/a
May(1992)	1.579	1.572	.148	.8	744	n/a
Jun(1992)	1.636	1.628	.165	.9	720	n/a
Jul	*	*	*	*	*	*
Aug	*	*	*	*	*	*
Sep	*	*	*	*	*	*
Oct(1991)	1.770	1.748	.288	2.6	740	n/a
Nov(1991)	1.626	1.622	.128	.9	720	n/a
Dec(1991)	1.698	1.686	.215	2.2	709	n/a

BY YEAR

YEAR	MIN	1%	5%	10%	25%	50%	75%	90%	95%	99%	MAX
1991-92	.6	1.3	1.4	1.5	1.6	1.7	1.8	2.0	2.1	2.4	3.4

YEAR	Arithmetic Mean	Geometric Mean	Arithmetic Std Dev	Range	N	Number of Exceedances
1991-92	1.710	1.695	.232	2.8	6322	n/a

n/a - not applicable * - no data

7.2 Summary of Data from Downtown Monitoring Station

Wind Summary for 1991-92
Fort McMurray Downtown Monitoring Station

Joint Wind Direction and Speed Frequency Distribution (no. of hours)

Wind Speed (km/h)

Dir	0-5	5-10	10-15	15-20	20-25	25-30	30-35	35-40	>40	TOTAL
N	343	186	95	27	0	0	0	0	0	651
NNE	99	20	4	0	0	0	0	0	0	123
NE	60	10	3	0	0	0	0	0	0	73
ENE	77	14	5	1	0	0	0	0	0	97
E	110	40	19	1	0	0	0	0	0	170
ESE	130	43	34	10	0	0	0	0	0	217
SE	498	486	175	44	10	0	0	0	0	1213
SSE	497	515	228	9	1	0	0	0	0	1250
S	80	43	21	7	0	0	0	0	0	151
SSW	29	16	18	8	0	0	0	0	0	71
SW	28	22	8	0	0	0	0	0	0	58
WSW	28	42	19	6	0	0	0	0	0	95
W	32	50	31	9	0	0	0	0	0	122
WNW	50	40	44	27	15	4	0	0	0	180
NW	141	285	117	47	8	2	0	0	0	600
NNW	303	356	277	74	9	0	0	0	0	1019
TOTAL	2505	2168	1098	270	43	6	0	0	0	6090

CALM = 163 hours
MISSING DATA = 323 hours

Joint Wind Direction and Speed Frequency Distribution (percent)

Wind Speed (km/h)

Dir	0-5	5-10	10-15	15-20	20-25	25-30	30-35	35-40	>40	TOTAL
N	5.2	2.8	1.4	.4	.0	.0	.0	.0	.0	9.9
NNE	1.5	.3	.1	.0	.0	.0	.0	.0	.0	1.9
NE	.9	.2	.0	.0	.0	.0	.0	.0	.0	1.1
ENE	1.2	.2	.1	.0	.0	.0	.0	.0	.0	1.5
E	1.7	.6	.3	.0	.0	.0	.0	.0	.0	2.6
ESE	2.0	.7	.5	.2	.0	.0	.0	.0	.0	3.3
SE	7.6	7.4	2.7	.7	.2	.0	.0	.0	.0	18.4
SSE	7.6	7.8	3.5	.1	.0	.0	.0	.0	.0	19.0
S	1.2	.7	.3	.1	.0	.0	.0	.0	.0	2.3
SSW	.4	.2	.3	.1	.0	.0	.0	.0	.0	1.1
SW	.4	.3	.1	.0	.0	.0	.0	.0	.0	.9
WSW	.4	.6	.3	.1	.0	.0	.0	.0	.0	1.4
W	.5	.8	.5	.1	.0	.0	.0	.0	.0	1.9
WNW	.8	.6	.7	.4	.2	.1	.0	.0	.0	2.7
NW	2.1	4.3	1.8	.7	.1	.0	.0	.0	.0	9.1
NNW	4.6	5.4	4.2	1.1	.1	.0	.0	.0	.0	15.5
TOTAL	38.1	33.0	16.7	4.1	.7	.1	.0	.0	.0	92.6

CALM = 2.48%
MISSING DATA = 4.91%

CO Summary Statistics for 1991-92
Fort McMurray Downtown Monitoring Station
Units are PPM (parts per million)

Ambient 1-hour average regulation = 13.0 PPM
Ambient 8-hour average regulation = 5.0 PPM

BY SEASON

SEASON	MIN	1%	5%	10%	25%	50%	75%	90%	95%	99%	MAX
Winter	.0	.1	.2	.2	.3	.4	.7	1.2	1.8	3.8	8.7
Spring	.1	.1	.2	.2	.3	.3	.5	.7	.9	1.6	3.5
Summer	.2	.2	.2	.2	.3	.3	.4	.5	.6	.8	1.0
Autumn	.0	.0	.1	.2	.5	1.2	1.5	1.8	2.1	3.2	4.9

SEASON	Arithmetic Mean	Geometric Mean	Arithmetic Std Dev	Range	N	Number of Exceedances 1 hour	8 hour
Winter	.641	.426	.677	8.7	2181	0(0.00%)	0(0.00%)
Spring	.413	.356	.288	3.4	2207	0(0.00%)	0(0.00%)
Summer	.363	.345	.121	.8	646	0(0.00%)	0(0.00%)
Autumn	1.087	.563	.683	4.9	1297	0(0.00%)	0(0.00%)

BY MONTH

MONTH	MIN	1%	5%	10%	25%	50%	75%	90%	95%	99%	MAX
Jan(1992)	.0	.2	.2	.2	.3	.4	.7	1.5	2.4	4.9	8.7
Feb(1992)	.2	.2	.2	.3	.3	.5	.7	1.2	1.8	3.8	4.5
Mar(1992)	.1	.1	.2	.2	.3	.4	.6	1.0	1.4	2.2	3.5
Apr(1992)	.1	.1	.2	.2	.3	.3	.4	.6	.7	1.4	2.1
May(1992)	.1	.1	.2	.2	.2	.3	.4	.5	.6	1.0	1.8
Jun(1992)	.2	.2	.2	.2	.3	.3	.4	.5	.6	.8	1.0
Jul	*	*	*	*	*	*	*	*	*	*	*
Aug	*	*	*	*	*	*	*	*	*	*	*
Sep	*	*	*	*	*	*	*	*	*	*	*
Oct(1991)	.0	.0	.0	.1	.2	.5	.8	1.1	1.5	2.2	3.2
Nov(1991)	.9	1.0	1.0	1.1	1.2	1.4	1.6	2.0	2.4	3.6	4.9
Dec(1991)	.0	.0	.2	.2	.3	.4	.7	1.0	1.5	2.0	3.1

MONTH	Arithmetic Mean	Geometric Mean	Arithmetic Std Dev	Range	N	Number of Exceedances 1 hour	8 hour
Jan(1992)	.712	.470	.888	8.7	742	0(0.00%)	0(0.00%)
Feb(1992)	.657	.516	.628	4.3	696	0(0.00%)	0(0.00%)
Mar(1992)	.540	.448	.394	3.4	743	0(0.00%)	0(0.00%)
Apr(1992)	.361	.325	.205	2.0	720	0(0.00%)	0(0.00%)
May(1992)	.336	.309	.161	1.7	744	0(0.00%)	0(0.00%)
Jun(1992)	.363	.345	.121	.8	646	0(0.00%)	0(0.00%)
Jul	*	*	*	*	*	*	
Aug	*	*	*	*	*	*	
Sep	*	*	*	*	*	*	
Oct(1991)	.542	.190	.471	3.2	577	0(0.00%)	0(0.00%)
Nov(1991)	1.524	1.469	.483	4.0	720	0(0.00%)	0(0.00%)
Dec(1991)	.557	.322	.422	3.1	743	0(0.00%)	0(0.00%)

BY YEAR

YEAR	MIN	1%	5%	10%	25%	50%	75%	90%	95%	99%	MAX
1991-92	.0	.0	.2	.2	.3	.4	.7	1.4	1.7	3.0	8.7

YEAR	Arithmetic Mean	Geometric Mean	Arithmetic Std Dev	Range	N	Number of Exceedances 1 hour	8 hour
1991-92	.625	.390	.592	8.7	6331	0(0.00%)	0(0.00%)

n/a - not applicable * - no data

COH Summary Statistics for 1991-92
Fort McMurray Downtown Monitoring Station
Units are COH units

Ambient regulation = 90% of values per month < 1.0 COH unit

BY SEASON

SEASON	MIN	1%	5%	10%	25%	50%	75%	90%	95%	99%	MAX
Winter	.0	.0	.0	.0	.0	.0	.1	.2	.4	.7	1.5
Spring	.0	.0	.0	.0	.0	.0	.1	.1	.2	.3	1.0
Summer	.0	.0	.0	.0	.0	.0	.1	.1	.1	.2	.3
Autumn	.0	.0	.0	.0	.0	.0	.1	.2	.3	.5	1.0

SEASON	Arithmetic Mean	Geometric Mean	Arithmetic Std Dev	Range	N	Number of Values > 1.0 COH unit
Winter	.094	.003	.141	1.5	2011	2(0.10%)
Spring	.052	.003	.063	1.0	2089	0(0.00%)
Summer	.037	.001	.053	.3	404	0(0.00%)
Autumn	.062	.000	.115	1.0	1240	0(0.00%)

BY MONTH

MONTH	MIN	1%	5%	10%	25%	50%	75%	90%	95%	99%	MAX
Jan(1992)	.0	.0	.0	.0	.0	.0	.1	.3	.5	.9	1.5
Feb(1992)	.0	.0	.0	.0	.0	.1	.1	.2	.3	.6	.8
Mar(1992)	.0	.0	.0	.0	.0	.0	.1	.1	.2	.4	1.0
Apr(1992)	.0	.0	.0	.0	.0	.0	.1	.1	.1	.2	.4
May(1992)	.0	.0	.0	.0	.0	.1	.1	.1	.1	.2	.4
Jun(1992)	.0	.0	.0	.0	.0	.0	.1	.1	.1	.2	.3
Jul	*	*	*	*	*	*	*	*	*	*	*
Aug	*	*	*	*	*	*	*	*	*	*	*
Sep	*	*	*	*	*	*	*	*	*	*	*
Oct(1991)	.0	.0	.0	.0	.0	.0	.1	.1	.2	.5	.6
Nov(1991)	.0	.0	.0	.0	.0	.0	.1	.2	.4	.7	1.0
Dec(1991)	.0	.0	.0	.0	.0	.0	.1	.2	.3	.5	.7

MONTH	Arithmetic Mean	Geometric Mean	Arithmetic Std Dev	Range	N	Number of Values > 1.0 COH unit
Jan(1992)	.114	.003	.180	1.5	682	2(0.29%)
Feb(1992)	.096	.008	.122	.8	585	0(0.00%)
Mar(1992)	.055	.002	.080	1.0	744	0(0.00%)
Apr(1992)	.042	.002	.054	.4	601	0(0.00%)
May(1992)	.062	.015	.047	.4	744	0(0.00%)
Jun(1992)	.037	.001	.053	.3	404	0(0.00%)
Jul	*	*	*	*	*	*
Aug	*	*	*	*	*	*
Sep	*	*	*	*	*	*
Oct(1991)	.046	.000	.088	.6	569	0(0.00%)
Nov(1991)	.077	.001	.133	1.0	671	0(0.00%)
Dec(1991)	.075	.002	.108	.7	744	0(0.00%)

BY YEAR

YEAR	MIN	1%	5%	10%	25%	50%	75%	90%	95%	99%	MAX
1991-92	.0	.0	.0	.0	.0	.0	.1	.2	.3	.5	1.5

YEAR	Arithmetic Mean	Geometric Mean	Arithmetic Std Dev	Range	N	Number of Values > 1.0 COH unit
1991-92	.066	.001	.110	1.5	5744	2(0.03%)

n/a - not applicable   * - no data

Wind Summary for 1991-92

Fort McMurray Downtown Monitoring Station

** calculation is for values greater than 1.0 COH unit **

Joint Wind Direction and Speed Frequency Distribution (no. of hours)

Wind Speed (km/h)

Dir	0-5	5-10	10-15	15-20	20-25	25-30	30-35	35-40	>40	TOTAL
N	0	0	0	0	0	0	0	0	0	0
NNE	0	0	0	0	0	0	0	0	0	0
NE	0	0	0	0	0	0	0	0	0	0
ENE	0	0	0	0	0	0	0	0	0	0
E	0	0	0	0	0	0	0	0	0	0
ESE	0	0	0	0	0	0	0	0	0	0
SE	0	0	0	0	0	0	0	0	0	0
SSE	2	0	0	0	0	0	0	0	0	2
S	0	0	0	0	0	0	0	0	0	0
SSW	0	0	0	0	0	0	0	0	0	0
SW	0	0	0	0	0	0	0	0	0	0
WSW	0	0	0	0	0	0	0	0	0	0
W	0	0	0	0	0	0	0	0	0	0
WNW	0	0	0	0	0	0	0	0	0	0
NW	0	0	0	0	0	0	0	0	0	0
NNW	0	0	0	0	0	0	0	0	0	0
TOTAL	2	0	0	0	0	0	0	0	0	2

CALM = 0 hours

MISSING DATA = 0 hours

Joint Wind Direction and Speed Frequency Distribution (percent)

Wind Speed (km/h)

Dir	0-5	5-10	10-15	15-20	20-25	25-30	30-35	35-40	>40	TOTAL
N	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
NNE	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
NE	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
ENE	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
E	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
ESE	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
SE	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
SSE	100.0	.0	.0	.0	.0	.0	.0	.0	.0	100.0
S	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
SSW	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
SW	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
WSW	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
W	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
WNW	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
NW	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
NNW	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
TOTAL	100.0	.0	.0	.0	.0	.0	.0	.0	.0	100.0

CALM = .00%

MISSING DATA = .00%

H2S Summary Statistics for 1991-92
Fort McMurray Downtown Monitoring Station
Units are PPM (parts per million)

Ambient 1-hour average regulation = .010 PPM
Ambient 24-hour average regulation = .003 PPM

BY SEASON

SEASON	MIN	1%	5%	10%	25%	50%	75%	90%	95%	99%	MAX
Winter	.000	.000	.000	.000	.000	.001	.001	.001	.001	.002	.011
Spring	.000	.000	.000	.000	.000	.001	.001	.001	.001	.002	.003
Summer	.000	.000	.000	.000	.000	.000	.000	.001	.001	.002	.004
Autumn	.000	.000	.000	.000	.000	.000	.001	.001	.001	.002	.002

SEASON	Arithmetic Mean	Geometric Mean	Arithmetic Std Dev	Range	N	Number of Exceedances 1 hour	Number of Exceedances 24 hour
Winter	.0006	.0001	.0006	.011	2172	1(0.05%)	0(0.00%)
Spring	.0006	.0002	.0004	.003	2203	0(0.00%)	0(0.00%)
Summer	.0002	.0000	.0005	.004	645	0(0.00%)	0(0.00%)
Autumn	.0004	.0000	.0004	.002	1299	0(0.00%)	0(0.00%)

BY MONTH

MONTH	MIN	1%	5%	10%	25%	50%	75%	90%	95%	99%	MAX
Jan(1992)	.000	.000	.000	.000	.000	.000	.001	.001	.001	.002	.003
Feb(1992)	.000	.000	.000	.000	.000	.001	.001	.001	.002	.002	.003
Mar(1992)	.000	.000	.000	.000	.000	.001	.001	.001	.001	.001	.002
Apr(1992)	.000	.000	.000	.000	.000	.000	.001	.001	.001	.002	.002
May(1992)	.000	.000	.000	.000	.000	.001	.001	.001	.001	.002	.003
Jun(1992)	.000	.000	.000	.000	.000	.000	.000	.001	.001	.002	.004
Jul	*	*	*	*	*	*	*	*	*	*	*
Aug	*	*	*	*	*	*	*	*	*	*	*
Sep	*	*	*	*	*	*	*	*	*	*	*
Oct(1991)	.000	.000	.000	.000	.000	.000	.000	.001	.001	.002	.002
Nov(1991)	.000	.000	.000	.000	.000	.000	.000	.001	.001	.001	.001
Dec(1991)	.000	.000	.000	.000	.000	.000	.001	.001	.001	.003	.011

MONTH	Arithmetic Mean	Geometric Mean	Arithmetic Std Dev	Range	N	Number of Exceedances 1 hour	Number of Exceedances 24 hour
Jan(1992)	.0005	.0001	.0005	.003	740	0(0.00%)	0(0.00%)
Feb(1992)	.0008	.0004	.0005	.003	694	0(0.00%)	0(0.00%)
Mar(1992)	.0007	.0003	.0004	.002	741	0(0.00%)	0(0.00%)
Apr(1992)	.0005	.0001	.0005	.002	718	0(0.00%)	0(0.00%)
May(1992)	.0005	.0002	.0004	.003	744	0(0.00%)	0(0.00%)
Jun(1992)	.0002	.0000	.0005	.004	645	0(0.00%)	0(0.00%)
Jul	*	*	*	*	*	*	
Aug	*	*	*	*	*	*	
Sep	*	*	*	*	*	*	
Oct(1991)	.0003	.0000	.0005	.002	579	0(0.00%)	0(0.00%)
Nov(1991)	.0002	.0000	.0004	.001	720	0(0.00%)	0(0.00%)
Dec(1991)	.0004	.0000	.0007	.011	738	1(0.14%)	0(0.00%)

BY YEAR

YEAR	MIN	1%	5%	10%	25%	50%	75%	90%	95%	99%	MAX
1991-92	.000	.000	.000	.000	.000	.000	.001	.001	.001	.002	.011

YEAR	Arithmetic Mean	Geometric Mean	Arithmetic Std Dev	Range	N	Number of Exceedances 1 hour	Number of Exceedances 24 hour
1991-92	.0005	.0001	.0005	.011	6319	1(0.14%)	0(0.00%)

n/a - not applicable * - no data

Wind Summary for 1991-92
Fort McMurray Downtown Monitoring Station
** calculation is for exceedances of the 1-hour regulation for H2S **

Joint Wind Direction and Speed Frequency Distribution (no. of hours)

Wind Speed (km/h)

Dir	0-5	5-10	10-15	15-20	20-25	25-30	30-35	35-40	>40	TOTAL
N	0	0	0	0	0	0	0	0	0	0
NNE	0	0	0	0	0	0	0	0	0	0
NE	0	0	0	0	0	0	0	0	0	0
ENE	0	0	0	0	0	0	0	0	0	0
E	0	0	0	0	0	0	0	0	0	0
ESE	0	0	0	0	0	0	0	0	0	0
SE	0	0	0	0	0	0	0	0	0	0
SSE	0	0	0	0	0	0	0	0	0	0
S	0	0	0	0	0	0	0	0	0	0
SSW	0	0	0	0	0	0	0	0	0	0
SW	0	0	0	0	0	0	0	0	0	0
WSW	0	0	0	0	0	0	0	0	0	0
W	0	0	0	0	0	0	0	0	0	0
WNW	0	0	0	0	0	0	0	0	0	0
NW	0	0	0	0	0	0	0	0	0	0
NNW	0	1	0	0	0	0	0	0	0	1
TOTAL	0	1	0	0	0	0	0	0	0	1

CALM = 0 hours
MISSING DATA = 0 hours

Joint Wind Direction and Speed Frequency Distribution (percent)

Wind Speed (km/h)

Dir	0-5	5-10	10-15	15-20	20-25	25-30	30-35	35-40	>40	TOTAL
N	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
NNE	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
NE	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
ENE	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
E	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
ESE	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
SE	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
SSE	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
S	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
SSW	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
SW	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
WSW	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
W	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
WNW	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
NW	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
NNW	.0	100.0	.0	.0	.0	.0	.0	.0	.0	100.0
TOTAL	.0	100.0	.0	.0	.0	.0	.0	.0	.0	100.0

CALM = .00%
MISSING DATA = .00%

NO2 Summary Statistics for 1991-92
Fort McMurray Downtown Monitoring Station
Units are PPM (parts per million)

Ambient 1-hour average regulation = .210 PPM
Ambient 24-hour average regulation = .110 PPM
Ambient annual average regulation = .030 PPM

BY SEASON

SEASON	MIN	1%	5%	10%	25%	50%	75%	90%	95%	99%	MAX
Winter	.001	.002	.003	.005	.008	.012	.020	.030	.037	.050	.069
Spring	.000	.001	.001	.002	.004	.006	.010	.018	.027	.038	.066
Summer	.000	.000	.000	.001	.001	.003	.005	.008	.010	.016	.021
Autumn	.000	.001	.002	.004	.006	.010	.016	.024	.030	.041	.047

SEASON	Arithmetic Mean	Geometric Mean	Arithmetic Std Dev	Range	N	Number of Exceedances 1 hour	Number of Exceedances 24 hour
Winter	.0152	.0120	.0107	.068	2106	0(0.00%)	0(0.00%)
Spring	.0085	.0056	.0078	.066	2205	0(0.00%)	0(0.00%)
Summer	.0040	.0018	.0033	.021	645	0(0.00%)	0(0.00%)
Autumn	.0122	.0095	.0085	.047	1232	0(0.00%)	0(0.00%)

BY MONTH

MONTH	MIN	1%	5%	10%	25%	50%	75%	90%	95%	99%	MAX
Jan(1992)	.001	.002	.003	.005	.007	.013	.020	.031	.039	.057	.066
Feb(1992)	.001	.002	.003	.004	.007	.012	.020	.030	.037	.052	.069
Mar(1992)	.000	.001	.001	.003	.005	.009	.016	.028	.034	.043	.066
Apr(1992)	.000	.000	.001	.002	.003	.005	.009	.014	.018	.031	.041
May(1992)	.000	.001	.001	.002	.003	.005	.008	.011	.015	.030	.047
Jun(1992)	.000	.000	.000	.001	.001	.003	.005	.008	.010	.016	.021
Jul	*	*	*	*	*	*	*	*	*	*	*
Aug	*	*	*	*	*	*	*	*	*	*	*
Sep	*	*	*	*	*	*	*	*	*	*	*
Oct(1991)	.000	.001	.002	.004	.007	.010	.015	.024	.029	.039	.045
Nov(1991)	.001	.001	.002	.003	.006	.010	.016	.025	.031	.042	.047
Dec(1991)	.002	.003	.005	.006	.008	.012	.019	.029	.036	.047	.062

MONTH	Arithmetic Mean	Geometric Mean	Arithmetic Std Dev	Range	N	Number of Exceedances 1 hour	Number of Exceedances 24 hour
Jan(1992)	.0156	.0121	.0113	.065	666	0(0.00%)	0(0.00%)
Feb(1992)	.0150	.0114	.0110	.068	696	0(0.00%)	0(0.00%)
Mar(1992)	.0123	.0081	.0101	.066	741	0(0.00%)	0(0.00%)
Apr(1992)	.0071	.0045	.0060	.041	720	0(0.00%)	0(0.00%)
May(1992)	.0062	.0047	.0050	.047	744	0(0.00%)	0(0.00%)
Jun(1992)	.0040	.0018	.0033	.021	645	0(0.00%)	0(0.00%)
Jul	*	*	*	*	*	*	
Aug	*	*	*	*	*	*	
Sep	*	*	*	*	*	*	
Oct(1991)	.0120	.0093	.0079	.045	512	0(0.00%)	0(0.00%)
Nov(1991)	.0124	.0096	.0088	.046	720	0(0.00%)	0(0.00%)
Dec(1991)	.0150	.0124	.0098	.060	744	0(0.00%)	0(0.00%)

BY YEAR

YEAR	MIN	1%	5%	10%	25%	50%	75%	90%	95%	99%	MAX
1991-92	.000	.000	.001	.002	.005	.008	.014	.024	.031	.044	.069

YEAR	Arithmetic Mean	Geometric Mean	Arithmetic Std Dev	Range	N	Number of Exceedances 1 hour	Number of Exceedances 24 hour
1991-92	.0111	.0068	.0095	.069	6188	0(0.00%)	0(0.00%)

n/a - not applicable   * - no data

NO Summary Statistics for 1991-92
Fort McMurray Downtown Monitoring Station
Units are PPM (parts per million)

No regulations

BY SEASON

SEASON	MIN	1%	5%	10%	25%	50%	75%	90%	95%	99%	MAX
Winter	.000	.001	.002	.002	.004	.007	.017	.039	.069	.174	.309
Spring	.000	.000	.001	.001	.002	.003	.006	.012	.021	.052	.206
Summer	.000	.000	.001	.001	.002	.003	.005	.008	.010	.016	.018
Autumn	.000	.000	.001	.001	.002	.005	.011	.027	.040	.100	.171

SEASON	Arithmetic Mean	Geometric Mean	Arithmetic Std Dev	Range	N	Number of Exceedances
Winter	.0175	.0082	.0307	.309	2106	n/a
Spring	.0060	.0028	.0104	.206	2205	n/a
Summer	.0037	.0025	.0030	.018	645	n/a
Autumn	.0112	.0046	.0190	.171	1232	n/a

BY MONTH

MONTH	MIN	1%	5%	10%	25%	50%	75%	90%	95%	99%	MAX
Jan(1992)	.000	.001	.002	.002	.004	.008	.019	.051	.098	.206	.309
Feb(1992)	.001	.001	.001	.002	.003	.007	.017	.041	.074	.171	.206
Mar(1992)	.000	.001	.001	.001	.002	.005	.011	.025	.038	.078	.206
Apr(1992)	.000	.000	.001	.001	.001	.002	.005	.009	.013	.035	.055
May(1992)	.000	.000	.001	.001	.002	.003	.005	.008	.010	.019	.053
Jun(1992)	.000	.000	.001	.001	.002	.003	.005	.008	.010	.016	.018
Jul	*	*	*	*	*	*	*	*	*	*	*
Aug	*	*	*	*	*	*	*	*	*	*	*
Sep	*	*	*	*	*	*	*	*	*	*	*
Oct(1991)	.000	.000	.001	.001	.002	.005	.011	.027	.035	.073	.115
Nov(1991)	.000	.000	.001	.001	.002	.005	.012	.028	.056	.143	.171
Dec(1991)	.000	.001	.002	.002	.003	.007	.015	.034	.055	.099	.136

MONTH	Arithmetic Mean	Geometric Mean	Arithmetic Std Dev	Range	N	Number of Exceedances
Jan(1992)	.0220	.0093	.0405	.309	666	n/a
Feb(1992)	.0174	.0082	.0294	.205	696	n/a
Mar(1992)	.0100	.0050	.0157	.206	741	n/a
Apr(1992)	.0042	.0020	.0059	.055	720	n/a
May(1992)	.0038	.0023	.0039	.053	744	n/a
Jun(1992)	.0037	.0025	.0030	.018	645	n/a
Jul	*	*	*	*	*	*
Aug	*	*	*	*	*	*
Sep	*	*	*	*	*	*
Oct(1991)	.0095	.0043	.0135	.115	512	n/a
Nov(1991)	.0124	.0047	.0221	.171	720	n/a
Dec(1991)	.0136	.0072	.0189	.136	744	n/a

BY YEAR

YEAR	MIN	1%	5%	10%	25%	50%	75%	90%	95%	99%	MAX
1991-92	.000	.000	.001	.001	.002	.004	.010	.023	.040	.117	.309

YEAR	Arithmetic Mean	Geometric Mean	Arithmetic Std Dev	Range	N	Number of Exceedances
1991-92	.0107	.0042	.0214	.309	6188	n/a

n/a - not applicable * - no data

NOX Summary Statistics for 1991-92
Fort McMurray Downtown Monitoring Station
Units are PPM (parts per million)

No regulations

BY SEASON

SEASON	MIN	1%	5%	10%	25%	50%	75%	90%	95%	99%	MAX
Winter	.001	.002	.004	.006	.011	.019	.035	.069	.104	.227	.352
Spring	.000	.001	.001	.002	.004	.009	.015	.027	.045	.086	.271
Summer	.000	.000	.001	.001	.002	.006	.009	.014	.017	.024	.029
Autumn	.000	.001	.002	.003	.007	.013	.026	.047	.068	.138	.215

SEASON	Arithmetic Mean	Geometric Mean	Arithmetic Std Dev	Range	N	Number of Exceedances
Winter	.0317	.0199	.0397	.351	2106	n/a
Spring	.0134	.0080	.0171	.271	2205	n/a
Summer	.0065	.0032	.0053	.029	645	n/a
Autumn	.0219	.0122	.0266	.215	1232	n/a

BY MONTH

MONTH	MIN	1%	5%	10%	25%	50%	75%	90%	95%	99%	MAX
Jan(1992)	.001	.002	.004	.006	.011	.020	.039	.080	.141	.259	.352
Feb(1992)	.001	.002	.004	.005	.011	.019	.033	.070	.107	.224	.255
Mar(1992)	.001	.001	.002	.003	.006	.013	.026	.051	.069	.118	.271
Apr(1992)	.000	.001	.001	.002	.004	.007	.013	.020	.027	.065	.086
May(1992)	.000	.001	.001	.002	.004	.007	.011	.017	.022	.044	.098
Jun(1992)	.000	.000	.001	.001	.002	.006	.009	.014	.017	.024	.029
Jul	*	*	*	*	*	*	*	*	*	*	*
Aug	*	*	*	*	*	*	*	*	*	*	*
Sep	*	*	*	*	*	*	*	*	*	*	*
Oct(1991)	.000	.000	.001	.002	.006	.011	.023	.047	.060	.112	.153
Nov(1991)	.000	.001	.003	.004	.008	.015	.028	.052	.087	.183	.215
Dec(1991)	.001	.004	.006	.007	.011	.018	.033	.062	.091	.144	.194

MONTH	Arithmetic Mean	Geometric Mean	Arithmetic Std Dev	Range	N	Number of Exceedances
Jan(1992)	.0367	.0215	.0501	.351	666	n/a
Feb(1992)	.0312	.0191	.0389	.254	696	n/a
Mar(1992)	.0209	.0124	.0244	.270	741	n/a
Apr(1992)	.0103	.0067	.0111	.086	720	n/a
May(1992)	.0089	.0061	.0081	.098	744	n/a
Jun(1992)	.0065	.0032	.0053	.029	645	n/a
Jul	*	*	*	*	*	*
Aug	*	*	*	*	*	*
Sep	*	*	*	*	*	*
Oct(1991)	.0188	.0098	.0209	.153	512	n/a
Nov(1991)	.0240	.0143	.0299	.215	720	n/a
Dec(1991)	.0276	.0193	.0278	.193	744	n/a

BY YEAR

YEAR	MIN	1%	5%	10%	25%	50%	75%	90%	95%	99%	MAX
1991-92	.000	.001	.002	.003	.006	.011	.023	.045	.070	.157	.352

YEAR	Arithmetic Mean	Geometric Mean	Arithmetic Std Dev	Range	N	Number of Exceedances
1991-92	.0206	.0106	.0294	.352	6188	n/a

n/a - not applicable   * - no data

O3 Summary Statistics for 1991-92
Fort McMurray Downtown Monitoring Station
Units are PPM (parts per million)

Ambient 1-hour average regulation = .080 PPM
Ambient 24-hour average regulation = .025 PPM

BY SEASON

SEASON	MIN	1%	5%	10%	25%	50%	75%	90%	95%	99%	MAX
Winter	.000	.000	.000	.004	.010	.020	.025	.031	.035	.038	.045
Spring	.000	.001	.007	.012	.024	.035	.042	.048	.051	.055	.061
Summer	.001	.003	.006	.008	.014	.020	.033	.041	.046	.053	.055
Autumn	.000	.001	.004	.007	.015	.022	.029	.033	.035	.038	.040

SEASON	Arithmetic Mean	Geometric Mean	Arithmetic Std Dev	Range	N	Number of Exceedances 1 hour	Number of Exceedances 24 hour
Winter	.0183	.0100	.0102	.045	2109	0(0.00%)	12(13.79%)
Spring	.0325	.0263	.0131	.061	2125	0(0.00%)	75(85.23%)
Summer	.0232	.0195	.0125	.054	647	0(0.00%)	7(25.93%)
Autumn	.0213	.0180	.0092	.040	1296	0(0.00%)	16(29.63%)

BY MONTH

MONTH	MIN	1%	5%	10%	25%	50%	75%	90%	95%	99%	MAX
Jan(1992)	.000	.000	.001	.005	.012	.020	.026	.030	.033	.038	.045
Feb(1992)	.000	.000	.001	.003	.012	.021	.030	.035	.036	.039	.045
Mar(1992)	.000	.000	.002	.006	.021	.034	.041	.044	.047	.052	.053
Apr(1992)	.000	.002	.010	.016	.026	.036	.042	.046	.051	.054	.057
May(1992)	.002	.004	.010	.014	.026	.036	.044	.051	.053	.057	.061
Jun(1992)	.001	.003	.006	.008	.014	.020	.033	.041	.046	.053	.055
Jul	*	*	*	*	*	*	*	*	*	*	*
Aug	*	*	*	*	*	*	*	*	*	*	*
Sep	*	*	*	*	*	*	*	*	*	*	*
Oct(1991)	.000	.001	.004	.006	.014	.019	.027	.032	.034	.037	.038
Nov(1991)	.002	.003	.005	.008	.017	.024	.029	.033	.035	.039	.040
Dec(1991)	.000	.000	.000	.005	.010	.015	.020	.030	.030	.035	.040

MONTH	Arithmetic Mean	Geometric Mean	Arithmetic Std Dev	Range	N	Number of Exceedances 1 hour	Number of Exceedances 24 hour
Jan(1992)	.0190	.0115	.0096	.045	669	0(0.00%)	4(14.81%)
Feb(1992)	.0204	.0122	.0111	.045	696	0(0.00%)	7(24.14%)
Mar(1992)	.0297	.0200	.0141	.053	661	0(0.00%)	17(62.96%)
Apr(1992)	.0333	.0285	.0118	.057	720	0(0.00%)	28(93.33%)
May(1992)	.0343	.0308	.0131	.059	744	0(0.00%)	30(96.77%)
Jun(1992)	.0232	.0195	.0125	.054	647	0(0.00%)	7(25.93%)
Jul	*	*	*	*	*	*	
Aug	*	*	*	*	*	*	
Sep	*	*	*	*	*	*	
Oct(1991)	.0199	.0159	.0093	.038	576	0(0.00%)	6(25.00%)
Nov(1991)	.0225	.0198	.0089	.038	720	0(0.00%)	10(33.33%)
Dec(1991)	.0157	.0082	.0093	.040	744	0(0.00%)	1(3.23%)

BY YEAR

YEAR	MIN	1%	5%	10%	25%	50%	75%	90%	95%	99%	MAX
1991-92	.000	.000	.004	.006	.015	.024	.034	.042	.046	.053	.061

YEAR	Arithmetic Mean	Geometric Mean	Arithmetic Std Dev	Range	N	Number of Exceedances 1 hour	Number of Exceedances 24 hour
1991-92	.0243	.0166	.0129	.061	6177	0(0.00%)	110(42.97%)

n/a - not applicable * - no data

Wind Summary for 1991-92
Fort McMurray Downtown Monitoring Station
** calculation is for exceedances of the 24-hour regulation for O3 **

Joint Wind Direction and Speed Frequency Distribution (no. of hours)

Wind Speed (km/h)

Dir	0-5	5-10	10-15	15-20	20-25	25-30	30-35	35-40	>40	TOTAL
N	78	73	54	19	0	0	0	0	0	224
NNE	26	13	3	0	0	0	0	0	0	42
NE	24	8	3	0	0	0	0	0	0	35
ENE	32	11	4	0	0	0	0	0	0	47
E	46	32	16	0	0	0	0	0	0	94
ESE	56	34	28	7	0	0	0	0	0	125
SE	160	181	110	33	10	0	0	0	0	494
SSE	127	132	49	8	1	0	0	0	0	317
S	30	23	17	7	0	0	0	0	0	77
SSW	17	11	18	8	0	0	0	0	0	54
SW	13	17	6	0	0	0	0	0	0	36
WSW	12	23	15	6	0	0	0	0	0	56
W	17	21	15	2	0	0	0	0	0	55
WNW	26	26	17	8	6	4	0	0	0	87
NW	81	175	84	25	4	1	0	0	0	370
NNW	119	158	161	48	7	0	0	0	0	493
TOTAL	864	938	600	171	28	5	0	0	0	2606

CALM = 20 hours
MISSING DATA = 14 hours

Joint Wind Direction and Speed Frequency Distribution (percent)

Wind Speed (km/h)

Dir	0-5	5-10	10-15	15-20	20-25	25-30	30-35	35-40	>40	TOTAL
N	3.0	2.8	2.0	.7	.0	.0	.0	.0	.0	8.5
NNE	1.0	.5	.1	.0	.0	.0	.0	.0	.0	1.6
NE	.9	.3	.1	.0	.0	.0	.0	.0	.0	1.3
ENE	1.2	.4	.2	.0	.0	.0	.0	.0	.0	1.8
E	1.7	1.2	.6	.0	.0	.0	.0	.0	.0	3.6
ESE	2.1	1.3	1.1	.3	.0	.0	.0	.0	.0	4.7
SE	6.1	6.9	4.2	1.3	.4	.0	.0	.0	.0	18.7
SSE	4.8	5.0	1.9	.3	.0	.0	.0	.0	.0	12.0
S	1.1	.9	.6	.3	.0	.0	.0	.0	.0	2.9
SSW	.6	.4	.7	.3	.0	.0	.0	.0	.0	2.0
SW	.5	.6	.2	.0	.0	.0	.0	.0	.0	1.4
WSW	.5	.9	.6	.2	.0	.0	.0	.0	.0	2.1
W	.6	.8	.6	.1	.0	.0	.0	.0	.0	2.1
WNW	1.0	1.0	.6	.3	.2	.2	.0	.0	.0	3.3
NW	3.1	6.6	3.2	.9	.2	.0	.0	.0	.0	14.0
NNW	4.5	6.0	6.1	1.8	.3	.0	.0	.0	.0	18.7
TOTAL	32.7	35.5	22.7	6.5	1.1	.2	.0	.0	.0	98.7

CALM = .76%
MISSING DATA = .53%

SO2 Summary Statistics for 1991-92
Fort McMurray Downtown Monitoring Station
Units are PPM (parts per million)

Ambient 1-hour average regulation = .170 PPM
Ambient 24-hour average regulation = .060 PPM
Ambient annual average regulation = .010 PPM

BY SEASON

SEASON	MIN	1%	5%	10%	25%	50%	75%	90%	95%	99%	MAX
Winter	.000	.000	.000	.000	.001	.002	.003	.008	.015	.040	.072
Spring	.000	.000	.000	.000	.000	.001	.002	.004	.011	.027	.066
Summer	.000	.000	.000	.000	.000	.000	.001	.003	.008	.019	.032
Autumn	.000	.000	.000	.000	.001	.001	.002	.005	.011	.024	.034

SEASON	Arithmetic Mean	Geometric Mean	Arithmetic Std Dev	Range	N	Number of Exceedances 1 hour	24 hour
Winter	.0038	.0010	.0069	.072	2171	0(0.00%)	0(0.00%)
Spring	.0023	.0003	.0053	.066	2203	0(0.00%)	0(0.00%)
Summer	.0014	.0000	.0034	.032	645	0(0.00%)	0(0.00%)
Autumn	.0024	.0005	.0041	.034	1030	0(0.00%)	0(0.00%)

BY MONTH

MONTH	MIN	1%	5%	10%	25%	50%	75%	90%	95%	99%	MAX
Jan(1992)	.000	.000	.000	.000	.001	.002	.003	.008	.015	.031	.050
Feb(1992)	.000	.000	.000	.001	.001	.002	.004	.010	.018	.045	.065
Mar(1992)	.000	.000	.000	.000	.001	.001	.002	.006	.014	.040	.066
Apr(1992)	.000	.000	.000	.000	.000	.001	.001	.005	.011	.024	.054
May(1992)	.000	.000	.000	.000	.000	.001	.001	.003	.009	.017	.019
Jun(1992)	.000	.000	.000	.000	.000	.000	.001	.003	.008	.019	.032
Jul	*	*	*	*	*	*	*	*	*	*	*
Aug	*	*	*	*	*	*	*	*	*	*	*
Sep	*	*	*	*	*	*	*	*	*	*	*
Oct(1991)	.000	.000	.000	.000	.001	.001	.002	.004	.005	.012	.017
Nov(1991)	.000	.000	.000	.000	.000	.001	.002	.008	.014	.026	.034
Dec(1991)	.000	.000	.000	.000	.001	.002	.003	.007	.011	.045	.072

MONTH	Arithmetic Mean	Geometric Mean	Arithmetic Std Dev	Range	N	Number of Exceedances 1 hour	24 hour
Jan(1992)	.0032	.0009	.0053	.050	739	0(0.00%)	0(0.00%)
Feb(1992)	.0047	.0017	.0080	.065	692	0(0.00%)	0(0.00%)
Mar(1992)	.0032	.0007	.0072	.066	741	0(0.00%)	0(0.00%)
Apr(1992)	.0021	.0002	.0047	.054	718	0(0.00%)	0(0.00%)
May(1992)	.0016	.0003	.0030	.019	744	0(0.00%)	0(0.00%)
Jun(1992)	.0014	.0000	.0034	.032	645	0(0.00%)	0(0.00%)
Jul	*	*	*	*	*	*	
Aug	*	*	*	*	*	*	
Sep	*	*	*	*	*	*	
Oct(1991)	.0018	.0008	.0019	.017	397	0(0.00%)	0(0.00%)
Nov(1991)	.0028	.0003	.0050	.034	633	0(0.00%)	0(0.00%)
Dec(1991)	.0034	.0007	.0072	.072	740	0(0.00%)	0(0.00%)

BY YEAR

YEAR	MIN	1%	5%	10%	25%	50%	75%	90%	95%	99%	MAX
1991-92	.000	.000	.000	.000	.001	.001	.002	.006	.012	.031	.072

YEAR	Arithmetic Mean	Geometric Mean	Arithmetic Std Dev	Range	N	Number of Exceedances 1 hour	24 hour
1991-92	.0027	.0004	.0057	.072	6049	0(0.00%)	0(0.00%)

n/a - not applicable   * - no data

THC Summary Statistics for 1991-92
Fort McMurray Downtown Monitoring Station
Units are PPM (parts per million)

No regulations

BY SEASON

SEASON	MIN	1%	5%	10%	25%	50%	75%	90%	95%	99%	MAX
Winter	1.5	1.7	1.9	2.0	2.2	2.3	2.6	3.0	3.2	3.8	6.3
Spring	1.0	1.3	1.7	1.7	1.9	2.0	2.3	2.6	2.9	4.0	7.3
Summer	1.8	1.8	1.9	1.9	1.9	2.0	2.0	2.1	2.1	2.3	2.8
Autumn	1.2	1.3	1.5	1.6	1.7	2.0	2.1	2.3	2.4	2.9	4.0

SEASON	Arithmetic Mean	Geometric Mean	Arithmetic Std Dev	Range	N	Number of Exceedances
Winter	2.420	2.390	.409	4.8	1244	n/a
Spring	2.148	2.109	.447	6.3	1950	n/a
Summer	1.973	1.971	.096	1.0	645	n/a
Autumn	1.947	1.925	.298	2.8	1152	n/a

BY MONTH

MONTH	MIN	1%	5%	10%	25%	50%	75%	90%	95%	99%	MAX
Jan(1992)	1.8	1.8	1.8	1.9	2.1	2.3	2.4	2.5	2.7	3.5	4.0
Feb(1992)	1.5	1.6	1.7	1.9	2.2	2.4	2.9	3.3	3.5	3.8	4.0
Mar(1992)	2.0	2.1	2.2	2.2	2.3	2.4	2.6	3.0	3.4	4.7	7.3
Apr(1992)	1.0	1.0	1.5	1.6	1.7	1.8	2.1	2.3	2.6	2.9	3.1
May(1992)	1.6	1.8	1.8	1.9	1.9	2.0	2.0	2.1	2.2	2.4	3.3
Jun(1992)	1.8	1.8	1.9	1.9	1.9	2.0	2.0	2.1	2.1	2.3	2.8
Jul	*	*	*	*	*	*	*	*	*	*	*
Aug	*	*	*	*	*	*	*	*	*	*	*
Sep	*	*	*	*	*	*	*	*	*	*	*
Oct(1991)	1.2	1.3	1.4	1.4	1.7	1.7	1.8	2.1	2.2	2.6	3.3
Nov(1991)	1.8	1.8	1.9	1.9	2.0	2.0	2.2	2.4	2.5	3.1	4.0
Dec(1991)	1.9	1.9	2.0	2.1	2.2	2.3	2.5	2.7	3.0	3.4	6.3

MONTH	Arithmetic Mean	Geometric Mean	Arithmetic Std Dev	Range	N	Number of Exceedances
Jan(1992)	2.280	2.264	.293	2.2	87	n/a
Feb(1992)	2.529	2.478	.514	2.5	414	n/a
Mar(1992)	2.558	2.523	.491	5.3	638	n/a
Apr(1992)	1.905	1.876	.336	2.1	568	n/a
May(1992)	1.981	1.977	.121	1.7	744	n/a
Jun(1992)	1.973	1.971	.096	1.0	645	n/a
Jul	*	*	*	*	*	*
Aug	*	*	*	*	*	*
Sep	*	*	*	*	*	*
Oct(1991)	1.753	1.736	.252	2.1	520	n/a
Nov(1991)	2.107	2.096	.231	2.2	632	n/a
Dec(1991)	2.376	2.357	.335	4.4	743	n/a

BY YEAR

YEAR	MIN	1%	5%	10%	25%	50%	75%	90%	95%	99%	MAX
1991-92	1.0	1.4	1.7	1.7	1.9	2.0	2.3	2.6	2.9	3.6	7.3

YEAR	Arithmetic Mean	Geometric Mean	Arithmetic Std Dev	Range	N	Number of Exceedances
1991-92	2.147	2.112	.416	6.3	4991	n/a

n/a - not applicable * - no data

7.3 Calculation Procedure for the Sign Test (Gilbert 1987)

The Sign test is appropriate for paired data sets when the underlying distribution is not known. Suppose we have two paired data sets X1 and X2 where:

$X1 = x1_i \quad i = 1$ to N;

$X2 = x2_i \quad i = 1$ to N; and

N is total number of times valid observations occur in both data sets.

The two-sided sign test null hypothesis is:

H_O: the individual observation $x1_i$ is as likely to be larger than the individual observation $x2_i$ as $x2_i$ is likely to be larger than $x1_i$.

The alternative hypothesis is:

H_A: the individual observation $x1_i$ is more likely to exceed the individual observation $x2_i$ than $x2_i$ is likely to exceed $x1_i$, or visa versa.

The Z statistic for which the null hypothesis is tested against is calculated by the following formulation:

$$Z = \frac{2B - n}{(n)^{1/2}}$$

where:

B is the number of times that $x2_i$ was greater than $x1_i$;

$n = N - t$; and

t is the number of tied observations ($x1_i = x2_i$).

If the data set is sufficiently large (N > 100) then the calculated Z statistic may be compared with the cumulative normal distribution to determine the significance of the difference between the two data sets. At a significance level of $\alpha = 0.05$ (95% confidence level), $Z_{1-\alpha/2} = 1.96$. If Z is less than or equal to -1.96 then we may conclude that $x1_i$ is more likely to be greater than $x2_i$ than $x2_i$ is likely to be greater than $x1_i$ at a 95% level of confidence. If Z is greater than or equal to 1.96 then $x2_i$ is more likely to be greater than $x1_i$ than $x1_i$ is likely to be greater than $x2_i$ at a 95% level of confidence. If Z is between -1.96 and 1.96 then $x1_i$ is as likely to be greater than $x2_i$ as $x2_i$ is likely to be greater than $x1_i$ (i.e. it is not possible to differentiate between $x1_i$ and $x2_i$ at a 95% level of confidence).

Gilbert, R.O. 1987. Statistical methods for environmental pollution monitoring. Van Nostrand Reinhold Company Inc. New York, New York. ISBN 0-442-23050-8.

7.4 Calculation Procedure for the Wilcoxon Signed Rank Test (Zar 1974)

The Wilcoxon signed rank test, an expansion of the sign test, is usually applied when the underlying distribution is symmetric. This test has more power to resolve differences in paired data sets than the sign test although, the test statistic is much more difficult to calculate. The null and alternative hypotheses are the same as those for the sign test.

Suppose we have two paired data sets X1 and X2 where:

$X1 = x1_i \quad i = 1$ to N;

$X2 = x2_i \quad i = 1$ to N; and

N is total number of times valid observations that occur in both data sets. Initially, the differences in the individual pairs of data are calculated ($x1_i - x2_i$ for i = 1 to N). Second, the absolute values of the differences are ranked from lowest to highest. If paired data are tied, than assign the average rank that would otherwise be assigned to these data. Next, the sign of the difference is affixed to the rank. Obtain T, which is the sum of the ranks with the less frequent sign. If tied data sets exist, calculate T by including tied values in the ranking procedure. After the tied values are ranked, delete ranks of the tied values.

The Z statistic for the Wilcoxon signed rank test is calculated using the following formulation:

$$Z = \frac{T - \dfrac{n(n+1) - m(m+1)}{4} - 0.5}{\left[\dfrac{n(n+1)(2n+1) - m(m+1)(2m+1) - (\Sigma T)/2}{24}\right]^{1/2}}$$

where:

n is the number of valid data pairs;

m is the number of tied data pairs;

$\Sigma T = \Sigma(t_i^3 - t_i)$; and

t_i is the number of tied pairs in each group of tied pairs. The Z statistic can then be compared to the cumulative normal distribution (if n > 100) in the same manner way as the sign test.

Zar, J.H. 1974. Biostatistical analysis. Prentice-Hall Inc. Englewood Cliffs, New Jersey. ISBN 0-13-076984-3.